

The Manufacture of

CONCRETE BLOCKS

and their use in

Building Construction

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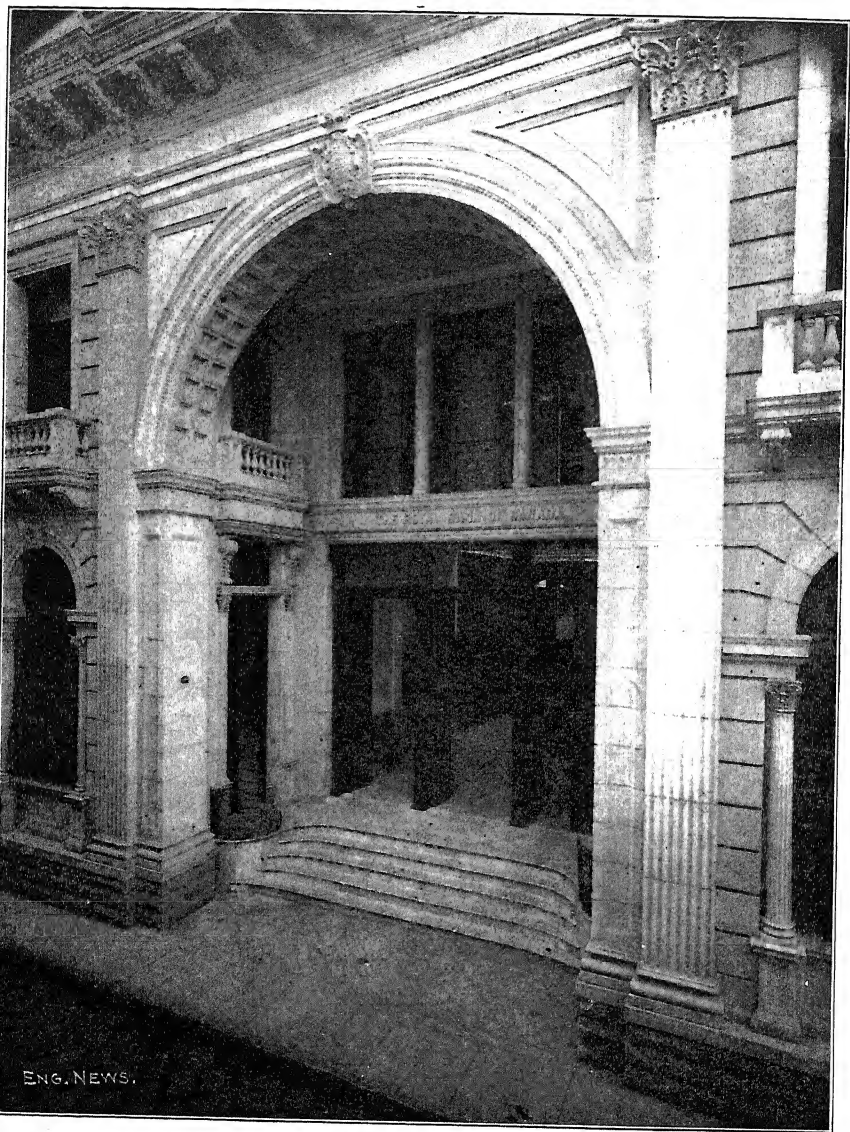


PLATE XIII.—THE ROYAL BANK OF CANADA BUILDING, HAVANA, CUBA.
Built by Purdy & Henderson, of Concrete Blocks Cast in Sand.

(See page 55.)

PREFACE.

The two most important applications of concrete in building construction at the present day are, first, reinforced concrete, and second, concrete block construction. Concerning the first, a vast amount of literature is available and the engineer desiring information finds technical periodicals and proceedings of engineering societies full of articles on reinforced concrete, while several excellent books are also available. Concerning the second, however, there has been an absolute dearth of literature and at the same time there is a demand for information, which it is the object of the present book to supply. It is made up of a series of articles by different authors, being those submitted in competition for money prizes of \$250 and \$100 offered jointly by "Engineering News" and "Cement Age," of New York City. The two papers printed in full are those to whose authors the prizes were awarded; the abstracts that follow the second prize paper are those parts of the ten papers not awarded prizes that contained data not in the prize papers or that presented the same information in greater length or with more force. Altogether the papers and abstracts form a practical treatise on the manufacture of concrete blocks and their use in building construction that at present stands alone in the literature relating to cement and concrete.



INTRODUCTION.

The symposium of expert knowledge and opinion which makes up the body of the present book presents for the first time an adequate discussion of the technology of concrete block manufacture. All the details of the industry are reviewed; the choice of locations for concrete block factories, the plant and equipment required, the selection of molding machines and processes, the manufacture, curing, shipping and storing of blocks, and, finally, their use in building construction, are all discussed. In view of all that these writers tell us it can hardly be doubted that the intrinsic merits of hollow concrete blocks will ultimately give them a prominent place among modern building materials. This assertion is made with a full realization of the limitations of the new material and of the conditions responsible for its present imperfect development. A material that at its best has the value of natural stone in its physical properties, that can be molded to any form to which stone can be cut, and that shape for shape and volume for volume is far less in cost than cut stone has just claim to a place in the world of architects.

The imperfect development of concrete blocks as a building material is a conceded fact. They are neither so widely used as they might be, nor, where used, do they give the results æsthetically and structurally that they are capable of being made to give. The responsibility for this condition rests partly on the architect who has done little to develop the architectural possibilities of the new material and partly on the block maker who has applied false standards of beauty and utility to his product.

Concrete block manufacture originated with the idea chiefly in the mind of producing an artificial stone capable of competing with brickwork in the construction of building walls. Incidentally, it may be stated that the great bulk of block manufacturers have never gotten away from this original conception. To compete with brickwork the manufacturer was compelled to sacrifice everything to cheapness. There was no possibility of doing anything at the low price set as a goal but produce a concrete block of the plainest and most economical form. The sole aim must be to duplicate the chosen size and shape of block as many times and as frequently as possible. The molding machines put on the market by various inventors were devised with the object chiefly in view of producing a cheap block. Their range of adjustability was limited to the

molding of half-blocks or quarter-blocks and to the production of such face patterns as could be managed by a simple change of face plates. On the other hand every possible mechanical device for increasing the output of blocks was utilized.

The result of this was that although working with a plastic material capable of almost limitless variations in form and texture the block maker succeeded only in producing one of the most rigidly regular and monotonously uniform building units ever put on the market. It is true that he produced a building material which was cheap, in fact, marvelously cheap, but it was one which he could not get specified by architects for the better class of buildings. Concrete blocks found use only in the plainest of wall construction, and here they struggled with brickwork for a place. In many cases the block makers sacrificed quality as well as flexibility of form and size, and thousands of blocks were made that were so porous, ragged and weak that they were dangerous to use. This still further damned the concrete block in the eyes of the architect.

We have spoken as if the conditions set forth were a thing of the past. They are this only in case of the better class of block manufacturers. The original idea that the mission of concrete blocks is chiefly to replace brick as a structural material still prevails with the majority of block makers and of block machine builders. The idea that cheapness is an end in itself is hard to get away from. In visiting recently a number of concrete block buildings under construction the writer was warned in each case that he would not see concrete block work at its best. Why? Forsooth the architect had refused to adapt his design to the standard blocks produced by the machine in use. He had planned his windows so that odd size blocks had to be made to fit the masonry to the window arrangement; he had demanded blocks shallower or deeper than the standard for certain courses where he thought that appearance would be enhanced by the change; he had demanded various face dimensions in order to secure a chosen bond that he considered desirable to the looks of the building; he had done other irregular things too numerous to mention. Wherein was the sin in all this, it may be asked. The blockmaker's answer was that it decreased the output of his machine, it increased the cost of the blocks, it increased the cost of the walls, it made concrete block work far more expensive than brickwork. The sin was that cheapness had been sacrificed.

In justice to the industry, it should be said that these ideas do not prevail with the most progressive and intelligent block manufacturers. They stand ready to execute the architect's plans, and they invite work on this basis. Every block manufacturer who desires to see his product go into building work of the better class must do the same. This means that his standard of attainment

must be the production of a material that will compete with the best natural stone for most building purposes. There will always remain cellar walls and cow barns to be built, and the single block man will do as well at these as any one, but the block manufacturer who intends to meet the quarryman in the architect's office and on an equal footing must stand ready to duplicate the quarryman's product size for size and shape for shape, and to do it for less money.

Duplication in the sense that it is urged here does not mean imitation. Only a few of those who have imbibed the broader doctrine of competition with natural stone have perceived this fact to the fullest degree. Imitation of natural stone has a small place, if any place at all, in the work of the concrete block maker. Honesty is as vital a principle in art as it is in trade. It is not honest to give to concrete a pretense of being what it is not. Moreover, concrete does not need the factitious aid of a simulated pitch face dressing in order that it may satisfy the eye in building construction. The pride of the worker in the material with which he works should alone prevent him for masking its identity.

The block maker may ask at this point if he is to abandon coloring, ornamentation and surface dressing for his product. The answer is, certainly not. Coloring may be used as freely as he chooses so long as it is used with taste, but it should not be used for the purpose of imitating a natural stone. In the same way the block maker may hammer-dress or chisel the face of his concrete, but he should do it not to make it resemble cut stone, but simply for the variation in surface texture in the same material that proper tooling may be made to furnish. In the matter of ornamentation the block maker is at equal liberty, but he had better do as the quarryman does and produce his ornamental work only to the order of the architect. There is far more than this to be said of the possibilities of surface finish and ornamentation in concrete work, but here we wish merely to prescribe a single broad precept to be obeyed in their use. Let the block maker shun imitation, and work for appearance always within the limitations of his material.

Concrete has so many advantages as a building material that it is frequently forgotten that it has its limitations. Concrete is concrete always. A natural stone may be granite or marble or onyx. Concrete has beauty of its own which may be properly enhanced in a variety of ways, but it has not the peculiar beauty of marble or of granite, and the architect cannot be expected to choose it when he wishes the color and texture effects peculiar to granite or marble. Furthermore, he will not, if he be an artist, choose an imitation. In conversation recently a very prominent architect said: "These block makers come in here and say, 'why don't you use concrete blocks? I can make a block that ten feet away you can't tell from red sandstone or marble or what not.' Now I

don't wish a concrete block that I can't tell from sandstone. I wish a concrete block that won't 'flower.' When I wish sandstone I can get sandstone." The rebuke in these statements is just; the business of the concrete block maker is to make concrete blocks and to make them without defects and not to make imitation sandstone.

The discussion so far has borne rather heavily on the shortcomings of the block maker, but the architect has been quite as negligent of his obligations if these may be assumed to exist at all in lending his aid in developing the possibilities of new structural materials. In a recent article we find the following statement: "The architect will be ready to use their product (concrete blocks) the moment it conforms to his conception of what constitutes a pleasing as well as a durable building material." Possibly it would not be professional good form, but it occurs to one not an architect that the architect's interest and activity might well go a step further. He might tell the block maker what he would consider to be pleasing, or failing in this he could at least tell him wherein his present product was unpleasing. This would help somewhat toward reaching the lofty plane where their product would conform to the architect's conception of what constitutes a pleasing building material. It would help matters considerably more, however, if the architect would devote a little study to ascertaining if possible how by adopting suitable architectural styles and finishes and forms of blocks, concrete blocks could be made to work out pleasingly to the eye in building construction. There is no insuperable obstacle to doing this; in fact, it has been done for a few special structures. The Royal Bank of Canada building at Havana, Cuba, illustrated in the body of this book, is one of these structures. One can point out others that are fully as enlightening as to the architectural possibilities of concrete blocks. They are equally enlightening to the block maker, for they show him what he must do if he is to claim a place with architects for his production in competition with cut stone.

EDITORS,

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The Manufacture of Concrete Blocks and Their Use in Building Construction.

First Prize Paper in ENGINEERING NEWS Competition.

H. H. Rice.

CONCRETE.

In any discussion of concrete blocks a clear conception of the theory of concrete is essential. We have heard and read a great deal of "artificial stone," and I wish that we might forget the term and banish from our minds the idea it conveys. I would that we might rather embrace the thought of concrete as a union of certain elements scientifically combined to form a material useful in construction because of its own distinctive merits, and not because of its resemblance to any other natural or artificial product. I am convinced that the effort toward imitation has caused half of the evils in connection with concrete construction. If we take it for what it is, rather than what it resembles, we shall find qualities, uses and advantages worthy of exhaustive research. Concrete is neither more nor less than a form of masonry readily adaptable to a large variety of uses because of the facility of production in any desired size or form. On account of the large number of aggregate members and the diversity in their shape and size, it requires the application of certain scientific methods in relation to the mortar, which are not required in masonry as the latter term is popularly used. The underlying principle of good concrete construction is that every particle of sand shall be thoroughly coated with cement, and that every piece of gravel or broken stone shall be thoroughly coated with the mixture of sand and cement. To the observance of this principle we must closely adhere if we would avoid those evils which have often followed the use of defective concrete, and by faithful adherence to this basic rule we shall produce a constructive material possessing such marked distinctive advantages that it easily rests upon its own merits.

MATERIALS.

In considering the materials used in the manufacture of concrete blocks, cement claims our first attention. The use of cement

in concrete construction is first actively brought to our notice by the Romans. They discovered that calcined clay finely ground and added to lime produced a substance which would set under water. The volcanic dust found near the village of Pozzuolo afforded an excellent hydraulic base for this lime-mortar, and the cement came to be called Puzzuolani. Modern orthographers have abbreviated this to Puzzolan, and the latter term in modern practice denotes any cement produced by the intimate mixing and grinding to extreme fineness, without subsequent calcination, of furnace slag, volcanic dust or burned clay and powdered hydrates of lime. Puzzolan cement attains great strength and toughness, but never becomes hard like a true Portland cement. It is not adapted for use except under water or in places where it can be constantly moist, as a dry atmosphere causes oxidation of the sulphides and resultant cracks and disintegration. Puzzolan cement is much lighter in weight than Portland, and is usually of a light lilac color instead of the well-known bluish gray. Freshly made pats of Puzzolan will show stains instead of the even color of Portland.

The manufacture of cement in England began about the year 1791, with Parker's cement, which was produced by calcining at a temperature sufficient to liberate the carbonic acid gas, and subsequently pulverizing, the argillo-calcareous nodules found in the Isle of Sheppey, containing approximately 70% carbonate of lime, 4% oxide of iron, 18% silica and 6½% alumina. Although the first discovery of cement rock in the United States was made 87 years ago, the process of manufacturing natural hydraulic cement is to-day, excepting improvements in kilns and grinding processes, substantially the same as used by Mr. Parker. The relative growth of the natural hydraulic cement industry and of the Portland cement industry is shown by the fact that of the former there were manufactured in the United States 2,030,000 barrels in 1880 and 4,866,331 barrels in 1904, as against 82,000 barrels of the latter in 1880 and 26,505,881 barrels in 1904, showing for the 24 years last past a gain of less than 140% for the natural hydraulic cement against a gain of 32,224% for the Portland.

Another cement which deserves passing notice is known as silica cement. It is merely a mixture of equal parts of Portland cement and sand ground to extreme fineness. It produces good results, but is in reality an adulteration, and there is no excuse, at the present low price of cement, for its purchase. It may be detected by the sediment in the jelly remaining after pouring a little muriatic acid on a small quantity of cement.

Portland cement is produced by calcining up to incipient fusion a mixture in definite proportions of argillaceous and calcareous substances, the resulting clinker being ground to extreme fineness. It is a curious fact that this clinker is incapable of hydraulic

activity before grinding, and that the hydraulicity of cement constantly increases with fineness of grinding. The name was first given to this class of cements on account of the resemblance in color to the famous Portland building stone of England. The essential elements are lime, silica and alumina. The industry was developed in Europe earlier than in America, and certain German brands have gained a world-wide reputation, though possessing no points of superiority over the American brands of the present day.

With the development of the rotary kiln, which was invented in England but perfected in the United States, a great gain was effected by placing the process of burning at all times under the direct control of the operator. Improvements in grinding machinery have similarly increased the efficiency in that department, while the relative proportions of ingredients are now carefully determined by constant chemical analysis, so that the product of an American Portland cement plant is of a very definitely known quality. In 1903 there were 78 factories in the United States making a true Portland cement. It is, therefore, evident that a wide range of choice is offered as to brands, and the concrete block manufacturer will be largely governed by location and freight rates, as the keen competition of recent years has resulted in a product so uniformly excellent that one can scarcely go amiss in buying from one of the larger companies.

In selecting a brand of known reputation one is able to profit by the exhaustive factory tests, and leave himself free to make his own tests on blocks of the finished concrete. And this is in some respects more satisfactory, for, while cement theoretically constitutes the principal element of strength in concrete, it is found in practice that the character of aggregates and the presence of deleterious substances in the sand have a very potent bearing on the ultimate strength. One should as far as possible avoid the use of different brands of cement, as greater uniformity of color is thus obtained. Prices are made on Portland cement by the barrel of 380 lbs. net, each barrel being the equivalent of four sacks of one cubic foot each. It may be procured in paper sacks or in cloth, the latter being billed at 10 cents each, and an equal credit allowed for all sacks returned in good condition to the factory. As a considerable saving in cost is made by large purchases, ample storage should be provided for a stock of cement, and precautions taken to preclude the possibility of its gathering moisture.

Sand is the next ingredient to be considered. Local availability and cost must, of course, govern to some extent. The sand should, however, be sharp, siliceous and clean. While some experimental tests have shown no loss of strength by an admixture of a certain percentage of clay, the best practice in building block work demands that the sand be free from loam, clay or other foreign

substances. If sand cannot be obtained in its natural state without such foreign materials, thorough washing is necessary to produce a reliable block. The general rule is, that the washing should continue until clean water is no longer discolored. The sharper the sand the greater will be the strength of the block. This is not hard to understand when we consider the necessity of the cement adhering to the sand facets, and also that the increase of sharpness produces a better bond among the grains of sand.

The color of sand is worthy of consideration, as it has more to do with the color of the block than most operators realize. Where a facing is used of a texture differing from the body of the block, it is very desirable to have a supply of white sand, similar to that used in the manufacture of glass, by the use of which a most beautiful face is secured without the addition of coloring matter. The quantity of sand should have the most careful consideration, as this will determine whether the block will be weak and porous or strong and dense in structure. The greater the proportion of sand, the more cement necessary to cause adhesion of the grains, and to fill the voids in the sand, but the amount of sand must not be less than necessary to fill the voids in the gravel or broken stone. It is not supposed that the average block maker will have at hand elaborate apparatus for scientific determination of voids and porosity, and therefore his best method of arriving at the proper proportions of sand to use with a given aggregate is to pour into a vessel filled with gravel or stone a measured quantity of water. The volume of water received will closely approximate the requisite amount of sand. This is very important on account of the variation in aggregates, and it is impossible without some test of this kind to say that a given mixture will result in a dense block unless the proposed mixture be so largely sand that an abnormal amount of cement is used or the grains are not thoroughly coated.

The gravel used in concrete block manufacture should contain a fair percentage of as large sizes as can be advantageously employed in the particular style of machine in use. It is better to have the gravel run from fine to coarse as the smaller sizes will tend to fill the spaces intervening between the large sizes, thus reducing the amount of sand necessary to fill voids. For this reason bank gravel is preferable, as it will often show such a gradation of sizes as to require little admixture of sand, but like sand it must be free from foreign materials. It is always advantageous to use as great a percentage of large sizes as possible without creation of voids as by this course greater strength is obtained from a given percentage of cement.

Where gravel is not available, crushed stone is used. In such cases care must be exercised to obtain stone which will be as strong

as the mortar, otherwise the concrete will be weakened by lack of strength in the aggregates. Exhaustive experiments on the relative strength of stone and gravel concrete show that at an early age the stone concrete is stronger but the gravel concrete makes a greater percentage of gain in strength with age.

Cinder concrete should not be used for walls intended to carry weight or to be subjected to lateral stress. Brickbats and similar materials are not permissible as aggregates in any class of concrete block construction.

The water used both in mixing and in curing should be clean and as free as possible from injurious minerals or vegetable matter. The amount of water will vary under different systems of manufacture, but under all it is an item of the greatest importance, without which chemical reaction is impossible.

MIXING.

In the matter of mixing, the first question which presents itself is what proportions shall be used. While the character of local materials makes it impossible to lay down any exact rule, some general observations may be helpful. The voids in sand, gravel or broken stone will show a variation ranging from 33% to 50%. Assuming that we have to deal with the larger percentage, a mix of 1-2-4 should be used, which is classified as the lowest grade of fat mixture. With certain character of aggregates, however, a lean mixture, as 1-3-5, may be advantageously employed. On the other hand, where gravel or broken stone is not used, the proportion should be 1 to 4 of cement and sand. A fat mixture possesses greater tensile strength than a lean, but compressive strength depends upon the thorough filling of voids. Ultimate success with any mixture can only be attained by the entire coating of every grain of sand with cement and every piece of stone or gravel with the sand-cement mortar. Hence it is evident that a lean mixture may with thorough and intelligent mixing prove more satisfactory than a fat mixture with hasty and indifferent mixing.

Where necessity compels mixing by hand, a platform or cement floor should be provided and the sand spread thereon, the cement then spread on the sand and turned twice before wetting. The water should then be applied by spray from a hose nozzle while the mixture is being turned, and when the mass is sufficiently moistened and the water evenly incorporated the gravel or stone (previously wet to avoid absorption) should be spread on this mortar and the whole turned at least twice. It is a good rule to continue the mixing until an even color is obtained.

Wherever possible, however, a power mixer should be installed as the initial cost is a matter of small consideration in view of the subsequent saving of labor and the greater uniformity obtained

in the mix. The most exhaustive comparative tests of hand and machine mixing of which record has been made were in connection with the construction of a pier in Duluth Harbor about five years ago. At seven days the hand-mixed concrete showed 53% of the strength of machine mixed; at 28 days 77%; at six months 84%, and at one year 87%.

There are a great many mixers on the market and it is necessary to exercise some judgment in selecting one which will thoroughly mix the ingredients and do it quickly and cheaply. The usual type of continuous mixer is not so well adapted to concrete block manufacture as are the batch mixers. It is very important, either in hand or machine mixing, to regulate the size of batches mixed so that no concrete shall be used which has been wet over half an hour, as cements usually take their initial set within 30 or 40 minutes after the addition of water, and if incorporated into blocks thereafter a certain portion of strength is lost.

The amount of water used in mixing is subject to the greatest variation, depending upon the style of machine used. A dry mixture is one in which just enough water is used to hold the cement and sand together. When compressed in the hand it will retain its shape, but will show no water and will not discolor the hand. in a more or less fluid condition. It will be seen that machines have been designed for using these different mixtures and the manufacturers of these various machines adhere with great tenacity to the particular degree of moisture required to obtain the best results under their respective methods of manufacture. Tests show, in a general way, that a dry mix has its greatest relative strength on short time tests while the use of a greater percentage of water increases the relative increase in strength with age. In the process of concrete block making a certain amount of water is absolutely essential to secure proper crystallization of the silicates and if it is not used in the mixture it must be supplied subsequently. Whatever method be used it is essential that the proportion of water be uniform, as the making of one batch wet and another dry will produce an unsightly variation in the color of the blocks.

Before leaving the subject of mixing, I wish to more fully impress upon the reader the importance of the most thorough manipulation of the mass. We have already seen that it is only by this method that voids can be eliminated and the greatest strength obtained. There are, however, other advantages resulting from an absence of porosity. The permeability of a concrete block is greatly reduced by added density and with sufficient attention to this matter the question of waterproofing is, at least in a measure, solved. Efflorescence is also practically overcome by making really dense and reasonably impervious blocks.

MANUFACTURE.

Our materials having been selected, our proportions having been determined, our mixture having been made, we are now ready for the actual manufacturing of concrete blocks. The processes which are offered for our consideration are three in number: Tamping, pressing and pouring.

The first is the method generally used in connection with the dry mixture, the material being shoveled into molds and gradually rammed to place as the mold is filling. To secure good results it is necessary that the tamping be thoroughly done, which involves a considerable amount of labor. Of late several automatic tampers have been placed on the market, calculated to lighten the labor, secure greater rapidity in manufacture and insure a more uniform A medium mixture is one in which water enough is used to flush to the surface when slightly tamped or compressed. A wet mixture is one in which an excess of water is used, the concrete being product. Tamping is better adapted to a dry mixture, as it will pack under the blows of the tamper and will not become displaced by lateral pressure as is the case if a medium or wet mixture be used under a tamper. This method is also more satisfactory with a cement and sand mixture than with coarser aggregates, as gravel or broken stone, unless comparatively small in size, does not readily yield the best results either in a dry mixture or under tamping. It may, therefore, be set down as a general rule that under tamped processes a dry mixture and aggregates of small size should be employed.

Under the systems using compression the advantage is claimed that a more uniform density is secured by the simultaneous application of pressure to all parts of the block. As the mold is entirely filled before the application of this pressure, the necessity for a dry mixture and fine aggregates is overcome, and a medium mixture is ordinarily employed containing aggregates of a size as large as can be conveniently accommodated in the particular mold in use.

The plan of operation under the poured processes is radically different from either of the others, as neither tamping or pressure is relied upon to compact the mass and bring the aggregates so close together as to secure necessary adhesion. Reliance is rather had upon the reduction of the cement to a fluid state, it being contended that by this method the aggregates are more thoroughly coated and perfect crystallization assured. An honest objection to this process appears to lie in the fact that the greater specific gravity of the cement is liable to cause it to settle to the bottom of the mold, and a practical difficulty is the large number of molds necessary on account of the length of time required for such a block to attain sufficient rigidity to be removed from the mold.

It is to be presumed that any one about to engage in the manufacture of concrete building blocks will provide himself with some one of the large number of machines now offered to the public, which are roughly divisible into five classes:

1. Upright machines for making hollow blocks.
2. Machines for making hollow blocks on the side.
3. Machines for making staggered blocks.
4. Machines operated by the wet process.
5. Machines making blocks for two-piece walls.

The first class of machine is, I take it, well known to most readers. The machines consist of removable hinged sides and upright interior cores. The blocks are made by tamping under the dry process and are, in the earlier designs of machines, removed on iron pallets, while some of the later machines avoid this expense by turning the mold over and releasing the block on wood or in some cases by making the block on a wooden board and lifting the mold bodily away from the block. The cores are in many machines mechanically raised and lowered, but in others the cores remain stationary while the bottom and sides are adjustable by various mechanical devices. It is evident that these variations have little influence on the manufactured block, and are merely labor-saving contrivances. The principle involved in the manufacture is in every case the same.

The second class is only different from the first in so far as the mold is turned on its side in order to facilitate facing. The face matter is first deposited and tamped, after which the cores slide into the mold laterally and the filling and tamping proceeds. The only thing gained over the first class is the opportunity to use a face mixture of different composition from the body of the block.

The third class eliminates the straight cross-partitions of the first and second classes and so disposes the cores that a staggered effect is produced. The object is to prevent the passage of moisture through the wall. This class of blocks have not been long on the market but seem to be meeting with considerable success, and are apparently an improvement as to the purpose they aim to accomplish.

The fourth class is totally different from others in process. They use a large number of light iron molds, having interior cores, and usually constructed to admit a circulation of air in the walls by making the body of the block of a less height and length than the faces. Into these molds the wet mixture previously described is poured and allowed to stand for several hours. The principal contentions of manufacturers of these molds are that the blocks are waterproof; that they are actual stone, and that they are cheaply made.

Class five is a radical departure from the others. Two-piece walls were brought out about three years ago and have distinctive features worthy of consideration. They are manufactured by pressure of a medium mixture, usually containing a considerable portion of large aggregates. This mixture is shoveled into the mold, pressed almost instantaneously, and forthwith released from the mold. Where it is desired to use a face mixture of color or texture other than the concrete forming the body of the block, a gage is used to rake out a quarter or three-eighths of an inch of the coarse concrete before it is pressed, and the face matter is applied on this loose mass and all pressed at one time. This bonds the face and body of the block very firmly together and as the pressure is applied directly to the face of the block a beautiful face of great hardness and density is obtained. This method of manufacture is made possible by the shape of the block, which consists of a face section with a long right-angle arm extending inwardly from the middle and a shorter arm extending from each end. In laying the blocks in a wall no portion of a block extends through the wall and, indeed, by leaving the interior vertical joints open to afford a free circulation of air no portion of a block on one side of the wall comes in contact with any block from the opposite side, thus precluding the passage of moisture and producing in effect two walls, tied by the overlapping of arms or webs in alternate courses, and affording a great resistance to lateral stress by the employment of the principle of bonding known as the header and stretcher bond of brick work or the three-quarter stone of ordinary masonry, while in thin partition walls the bonding is by the system of through-stones.

CURING.

While the importance of curing leads us to consider it under a separate heading, it is well to understand distinctly that curing is a most important part of the manufacturing process. It is in the adaptability for effective and thorough curing that block construction differs essentially from all other systems of concrete construction, and therein does it possess a distinct advantage. It is, however, necessary that the importance of curing be firmly impressed upon the block maker and every effort made to secure the best results. I believe that to a failure to appreciate the advantages of scientific curing is due, more than to any other cause, the difficulties encountered by many manufacturers. To secure strength and durability in concrete blocks it is necessary that the cement shall have a certain amount of water to produce the chemical reactions resulting in crystallization of the silicates of lime and aluminum. If the requisite amount of water be not used in the initial mixing it is evident that it must be subsequently sup-

plied. However, this application of moisture is often made in a manner so irregular and haphazard that the cement is allowed to take its final set under the most unfavorable conditions and as a consequence a great portion of its strength is lost.

The great point to be remembered is that uniform conditions must be maintained. If a block be wet in the morning, dry at noon and wet again at night it is not hard to see why it will lack strength when tested. Again, it is essential that every part of the block shall have the same treatment. Varying degrees of moisture or exposure to the sun will cause variation in contraction and result in cracks and liability to subsequent disintegration, as well as variation in color. It is, therefore, essential that the blocks be sprinkled at regular intervals, and so frequently that there is no drying. The blocks should not, during curing, be allowed to become dry enough to begin to turn white. The sprinkling should be thorough, evenly reaching every part of the block and should be accomplished by use of a gentle spray which will not deface the freshly made blocks. Moreover, the blocks must be protected from the sun to secure necessary uniformity of conditions. A free circulation of air among the blocks is desirable, and it is bad practice to allow blocks to rest in contact with one another in the curing shed. Most manufacturers are anxious to make a record as to speed and cost, and rush blocks into a wall while too green. The result is that the exposed side of the wall dries more rapidly than the interior and the part which should possess the greater strength becomes the weaker and may disintegrate in a few years.

Blocks made by the dry process should have the most careful curing for at least twenty days after coming from the molds, while from a week to ten days of similar treatment will suffice for blocks made from a medium mixture. Blocks made by the wet process contain an excess of water which is subsequently taken up by the cement so that they will require little water in curing except on exposed surfaces, but the maintenance of uniform conditions and shelter from the sun is quite as important as under either of the other processes.

The curing of blocks in winter has been successfully conducted by protection from freezing for the first few days. As soon as the block acquires sufficient rigidity to protect itself from the danger of expansion cracks, freezing merely suspends the setting but does not prevent its resumption upon a rise in temperature. However, curing under these conditions requires more time and a constant exercise of the greatest caution.

In view of the fact that crystallization is quickened by a rise in temperature experiments have been made on curing blocks in a live steam room. The results have been very satisfactory as to time, making it possible to lay blocks in the wall within 48 hours

after molding. It is still an unsettled question, however, as to how great an extent this artificial acceleration of the chemical reaction secures the full strength of the cement.

FACING.

Authorities differ as to the advisability of applying a thin facing of different composition from the material composing the body of the block. As the manufacture of concrete blocks sprang from monolithic construction, it is believed that the opposition to facing originated from the bad results obtained by efforts made to face that class of work. The cause of those ill effects is, however, not difficult to determine when one considers that in such construction the coarse concrete is deposited in forms and allowed to set for some time before the removal of those forms, and that the face matter is afterward applied and the surface troweled. This process is wrong for two reasons: First, the backing having already taken its set does not, even though thoroughly wet, allow ready adhesion of the facing which is, therefore, liable to separation and cracking. Second, the troweling draws the neat cement to the surface and results in hair cracks owing to the variation in contraction. The fact that very many of the machines now on the market advertise facility of facing as a strong point in favor of their process indicates that facing is growing in favor, and it is certain that the efforts made by the various manufacturers to satisfactorily solve this problem have resulted in greater success than was generally anticipated. It will, therefore, be well to consider some points in connection with methods calculated to secure the greatest efficiency in this line.

The objects of facing are three:

1. Saving in cost of material.
2. Securing a beautiful surface.
3. Making the surface more dense and impervious.

The saving in material is effected by using a coarse lean mixture for the body of the block and applying a face of fine fat mixture varying from a quarter to a half inch in thickness. The beauty of surface results from the opportunity afforded of using expensive selected material for this thin face which would make the cost prohibitive if used throughout the entire block. The use of the fat mixture with the fine aggregate makes it possible to produce a face which is practically impermeable and possesses much greater density than the mixture ordinarily employed for the body of the block.

The selection of sand for the face mixture is worthy of most careful consideration, and here we are not dependent upon local availability as the small quantity required warrant shipping from a considerable distance to ensure the desired result. As mentioned

in a previous section, a fine white sand of such sharpness as used in glass factories is suitable, and sharp screenings from crushed granite also afford an excellent material.

The face mixture may be made in proportions varying from 1-1 to 1-3 and requires greater care in mixing than concrete, as there is a tendency to roll up and become lumpy, which may be overcome by screening the wet mixture immediately before use. The best results are obtained by using a little more water than usual in the body of the block and applying the face matter in about the consistency of an ordinary dry mix; the face will then, by capillary attraction, draw moisture from the body of the block. It will be noted that the process is, in this respect, directly opposite to the method ordinarily used in sidewalk construction.

Whether the block be made by tamping or pressure, it should be so arranged that direct compression of the face is obtained and there must be no interval of time between the manufacture of the face and body of the block, but both must be made at one simultaneous operation, so that the face matter may be thoroughly imbedded into the loose coarse concrete and become an integral part of the block with no distinct line of cleavage between the two. It is only thus that separation and cracks may be avoided and a product of great durability assured.

Many block makers produce desired colors by mixing dry colors with the face matter. Only mineral colors should be used, free from deleterious chemicals, acids or greases. As several manufacturers are now offering a variety of colors especially prepared with a view to obviate the loss of strength frequently resulting from an admixture of coloring matter, and as these specially prepared colors have given general satisfaction it is well to procure them and avoid the expense and annoyance incident to experimentation along original lines of coloring. These colors are thoroughly mixed with the dry facing sand before the cement is added, and used in such proportions that a freshly made block will be two shades darker than required when cured.

The form of face is a matter which is given much attention by the manufacturers of concrete block machines. Those in most common use are smooth face, bevel edge, corrugated or ribbed, pitch or rock face, and special designs of ornamental faces. In the use of various designs of these face plates it is desirable, at all times, to bear clearly in mind the fact that concrete blocks have a place of their own in building construction, that they are capable of such artistic finish that they may rest upon the merit of their own beauty, and that they are not dependent for their popularity upon imitation of any other material commonly used in the construction of buildings. It is to this idea of imitation which has been so prevalent in the earlier stages of the development of this industry, and

to the consequent failure to appreciate the artistic possibilities of concrete block construction, that much that is monotonous, much that is artificial, much that is unpleasing and abhorrent in concrete block architecture is chargeable.

TESTING.

It is very desirable that tests of tensile and compressive strength be made from time to time. While the customary method of testing cement briquettes is useful, it gives us no information concerning the strength-giving properties of the other materials used, and it was found in a series of tests recently conducted at the University of Michigan that the character of sand, gravel or broken stone, the presence of earthy matter, the use of an excessive amount of sand, the size of aggregates and the thoroughness of mixing, all have an important bearing upon the strength of the finished block. A block for testing should be not less than 28 days old, and to ascertain the relative tensile strength should be supported by knife edges upon the platen of the testing press with the load resting upon the center of the block. Compression tests may afterward be made upon fragments of the same block.

COST.

Too much has been written about the low cost of concrete blocks. While they may be placed in the wall at a lower cost than any natural material of equal quality, yet the distinctive points of excellence peculiar to concrete block construction are of far greater moment than the saving in cost. Many block makers have considered low cost the chief end to be attained and have sacrificed quality to its attainment, while the highest success can only be secured by those who make uniformly superior blocks and keep the cost down by intelligent management and judicious systematization of the work of manufacturing. The literature of every manufacturer of concrete block machines contains statements of cost, and these figures may be considered as truthfully compiled from the results of work intelligently conducted under favorable conditions. A paper read at a recent meeting of the Iowa Cement Users contains a rather full report as to cost, being compiled from reports obtained from a large number of block makers. The results were computed to ascertain the average cost per square foot of 10-in. wall, and were as follows:

Sand	2.0 cts.
Cement	4.5 "
Labor (manufacture and curing)	3.8 "
Total	<u>10.3 cts.</u>

For 8-in. walls, 1 ct. less.

For 12-in. walls, 1 ½ cts. more.

The cost of labor and mortar for laying averaged five cents per

foot. The above figures do not take into consideration the cost of administration or incidentals.

CONSTRUCTION.

In laying blocks in a wall it is necessary that they be first thoroughly moistened to prevent absorption of water from the mortar and consequent insufficiency of adhesion. The best mortar for laying concrete blocks is composed of one part cement, three sand and one slaked lime. The admixture of this proportion of lime increases the adhesiveness and gives to the mortar a body which makes it trowel with greater facility. To produce satisfactory results it is necessary that joints be uniform. Usually a quarter inch joint will produce the best effect.

The size of blocks varies greatly with the different machines and processes and it would seem, as suggested at the June meeting of the Concrete Block Machine Manufacturers' Association, that the public good might be greatly subserved by the exercise of a spirit of co-operation looking toward the adoption of more universal standards of sizes. There is no apparent reason why the size of concrete blocks should not be as standard as the size of brick. What this size should be is not material so long as symmetrical proportions are maintained between the width and length by observing the rule of multiples. Whatever size may ultimately be adopted should have allowance made for width of mortar joints so that the block when laid in the wall will, with its mortar joint, be of the determined dimensions.

Until such action shall be taken it is impracticable to prepare any extensive sets of plans for the construction of concrete buildings. The only important respect in which such plans would differ from those for buildings of other materials would be in the adaptation of dimensions to the size of the blocks and the placing of openings in conformity thereto, but with the present diversity of sizes a series of plans adapted to the product of one machine would be no better suited to the product of another than would the plan of an ordinary brick house.

A few manufacturers provide machines for making sills and lintels of four and five feet lengths, but it is not practicable to construct machines along present lines for the larger sizes so often required, and it may be fairly said that in general the block maker is thrown upon his own resources for the construction of these parts of a building. Some simple reinforcement may be used and these parts easily and quickly constructed in wooden molds made in any block factory. The customary method of troweling the surface has been the cause of most of the trouble in making sills and lintels. As previously mentioned this troweling causes checks and hair cracks, rendering the work unsightly and liable to weather badly.

This trouble is eliminated by constructing a knock-down mold (clamped at the ends) of the best straight-grained surfaced lumber, putting in the face matter first and backing with coarse concrete, the latter as wet as practicable. Of course it has often been observed that faced work constructed in lumber forms shows the grain of the wood. To obviate this the interior surfaces of the mold and bottom board should be carefully sandpapered and shel-laced.

Of the various methods used by different systems for supporting floor joists the use of steel joist hangers is undoubtedly superior. It not only permits of the unbroken construction of the wall but also possesses a distinct advantage inasmuch as the floors are entirely free from the walls, so that the burning of the former will not cause the latter to fall.

As it is impossible to drive nails into concrete, it becomes necessary to provide some means for fastening door and window trim, base boards, picture molding, etc. This is best accomplished by the use of a very excellent metal wall plug now on the market which is laid in the mortar joints as the wall is building.

There is no reason in the nature of things why plastering should not be applied directly to the interior of a wall built of concrete blocks. Indeed, if the wall be regularly laid and the interior unfaced the surface is such that the priming coats may be omitted and a coat of hard plaster applied directly to the blocks. One must, however, be sure either that the blocks are waterproof or that the construction of the wall is such as to prevent the passage of moisture. Without the presence of one or the other of these safeguards, furring and lath are as necessary as with ordinary solid brick walls.

Not only may the superstructure be of concrete blocks, but the foundation as well; the latter should be of a little heavier wall and should rest upon concrete footing the depth of which must be determined by the character of the soil and the width by the load which the ground will sustain without deflection. It is very important that these matters be definitely ascertained and a considerable factor of safety allowed inasmuch as any settlement will result in cracked walls.

The widths of walls considered necessary for ordinary buildings by the best authorities on concrete block construction are approximately as follows:

For one-story buildings	8-in. walls.
For two-story buildings	10-in. "
For three-story buildings	12-in. and 10-in. "
For four-story buildings	15, 12 and 10-in. "

In some cities the Department for Inspection of Buildings have granted permits without question for constructing walls of the

widths mentioned. In other places rival interests have caused to be passed ordinances prejudicial to the concrete block industry. Such opposition is necessarily short-lived providing block makers use diligence in universally maintaining that high standard of excellence of which the industry is easily capable.

The matter of fireproofing of buildings is probably now receiving greater attention than at any previous time in the world's history. The attention of architects and insurance experts was actively drawn to concrete construction by the great fire-resisting qualities manifested in the Baltimore conflagration and in numerous fires of more recent date, and the interest thus aroused has led to a number of experimental fires the results of which prove beyond a doubt that well-made concrete is not merely non-inflammable but that it withstands the conflagration test far better than any other building material in use at the present day. It is generally considered that concrete will disintegrate under the same extremes of temperature, or the same alternate subjection to fire and water, that would cause decomposition in the stone composing the aggregate. This view is erroneous inasmuch as the aggregates in properly made concrete are protected by the surrounding matrix, and the latter resists fire far better than any stone, granite not excepted. Here, then, we see the prime importance of obeying the law mentioned in the first section of this paper: Let every grain of sand be thoroughly coated with cement, and let every piece of gravel or stone be thoroughly coated with the sand-cement mortar.

The Manufacture of Concrete Blocks and Their Use in Building Construction

Second Prize Paper in ENGINEERING NEWS Competition.

Wm. M. Torrance, M.W.S.E.

Anyone who contemplates the manufacture of concrete building blocks, or construction by their use, should study the following questions carefully:

1. Proper ingredients entering into concrete for successful work.
2. Forms of blocks. Patent rights and their value.
3. Cost (1) Establishing an industry.
(2) Cost of product.
(3) Comparative cost of building of concrete blocks and other materials.
4. Associated industries.
5. Engineering and Architectural considerations.
6. Success so far achieved in the industry.
7. Advantages possessed by an Engineer or Architect over others in handling a successful business.

1. PROPER INGREDIENTS.

Concrete is generally defined as an aggregate of cement with sand and gravel, or with sand and crushed rock, or simply with crushed stone and the crusher dust and screenings from same, mixed with the proper proportion of water to make a material which can be molded into any desired shape while in a fluid, plastic, or semi-plastic state, or only sufficiently damp to pack solid when tamped; and which will "set" in this molded shape without deformation, making an artificial stone.

Contractors and others have often used too little cement, or cement of poor quality, in railroad work or other structures, and the resulting failures and poor appearance have tended to discredit concrete as a building material. In establishing a concrete block business, therefore, no attempt should be made to use any but the best of materials, including the water used, put together in a correct manner and in proper proportions. None but the best

CONCRETE BLOCKS

quality of Portland cement should be used by a concrete block manufacturer if he wishes to have permanent success.

It is the best practice (in fact, the only correct practice) that concrete should contain somewhat more than enough material of each size of grain to fill the voids in the material of the next larger grain. Thus there should be no less cement than will fill the voids in the sand, and no less sand than will fill the voids in the gravel or crushed rock. In many of the so-called "concrete" blocks on the market, only sand and cement can be used, which do not make a "concrete" block in the ordinary use of the term "concrete," but rather a "mortar" block; and this is not so strong or so durable a stone as one to which body has been given by addition of crushed rock or gravel. For any kind of good results with such "sand and cement" blocks, however, more than enough cement must be used to fill the voids of the sand, or the result will be a porous product that will not withstand the elements, as a porous product is bound to result, whatever the method used in making the aggregate; and if too small a proportion of cement is used, actual disintegration is bound to take place within a few years or months. Of course, if the outer exposed face is composed of a mixture which is made in the correct proportions, it would tend to protect a cheaper mixture behind; but large railroad companies and others who have used concrete extensively during a long term of years are practically unanimous in making the whole body of a concrete structure, however thick, of concrete in correct proportions to fill the voids, and it is certain that the best work in concrete must always be so done. If a richer facing mortar is applied, or if the front portion of the block is made richer than the remainder, great care is necessary to see that there is left no plane or joint of cleavage.

Large users of concrete are very strict in their specifications, requiring rigid inspection and tests. The N. Y. C. & H. R. R. R. Co., tests, for instance, are so rigid, that of all the various brands of cement on the market, their inspection bureau now only accepts seven, which are the only ones used in the very extensive concrete work being done by that company. Other large users are fully as exacting. The result is that most of the inferior cement sold is sold to the smaller consumer. He pays on the average a price for cement as high or higher than the large consumer pays, as he takes it in so much smaller lots; and what he gets is very apt to be cement that would not pass rigid tests or fill proper specifications.

Not only the cement but also the other ingredients of the concrete should pass good specifications and tests. Every manufacturer of concrete blocks should be sure that the ingredients are of the

best by making proper tests, and, no matter what the provocation, he should never "rob the job" by diminishing the cement below the correct proportion, or by using a poor quality of water, cement, sand, gravel, or crushed rock (the reader is referred to the standard specifications of the U. S. Government, or those of any large railroad company for specifications for good concrete ingredients): This is imperative if the prejudice against concrete blocks is to be overcome. A large proportion of such "concrete" block construction as is now going on in small places throughout the country would, in large cities, be prohibited by the rules of the building departments because of the defective material used, or because the method of mixing is not satisfactory.

Concrete is mixed either "dry," "medium" or "wet." "Dry" concrete is made by use of only so much mixing water as will make it of the consistency of molding sand when being worked. This is then compacted by tamping, as molding sand is tamped.

"Medium" concrete is made by use of enough mixing water so that water will flush to the surface by tamping or pressure.

"Wet" concrete is made by the use of enough mixing water so that the concrete when mixed will pour, or into which, when first deposited, men will sink at least to their ankles.

There have always been strong advocates of all of these processes, but the tendency has been for large users of concrete to change from the "dry" to the "medium," or to the "wet." This change has been caused by results of many comparative experiments and tests.

Specifications of many companies require "wet" concrete now, where the same companies formerly specified "medium," and it would now be hard to find standard specifications which required a "dry" concrete. Certainly the "wet" and "medium" grades are less porous than the "dry." "Dry" concrete, as made into blocks by many companies, also suffers from lack of gravel or crushed rock, which cannot be used in the process.

The catalogue of one of the larger manufacturers of concrete block machines recommends the following proportions for the mixture of cement and sand to be used in the blocks:

For foundation walls: 1 part cement, 3 parts sand.

For first floor walls: 1 part cement, 4 parts sand.

For second floor walls: 1 part cement, 5 parts sand.

For third floor walls: 1 part cement, 6 parts sand.

It is difficult to reconcile this sort of a recommendation to any sort of reason. The voids in an average sand are not less than about 30%. Therefore, in the 1:3 mixture, the voids will probably be well filled, and a compact, waterproof (or practically waterproof) concrete might result with proper workmanship, but with

the 1:6 mixture, probably only a little over 50% of the voids are filled. Blocks so made will be sure to absorb and hold a great deal of moisture, and buildings made of them will be damp. Such blocks will also disintegrate easily through the action of frost.

Although concrete made of ingredients aggregated in the correct proportion may be nearly waterproof, no concrete as ordinarily made will be entirely so. On this account, there are in use many materials or devices for making concrete impervious to moisture. One firm handles a sort of jelly which is used in proportion of one part of jelly to five parts of the cement used. This is mixed in with the other ingredients of the concrete or in the facing mortar. Another firm handles a "waterproof compound" which it "puts up in paper sacks of 40 pounds each, and which is to be used with from fifty to one hundred times its weight of cement." This firm advertises that "cement with one per cent. of the waterproof compound, with five parts sand gives a more impervious mortar than ordinary untreated cement with two parts sand." Another firm, of international reputation, advertises the use of a "stone liquid" for coating brick work, stone masonry work, or concrete. This is applied as a paint, the surface absorbing the liquid, which becomes an insoluble compound, filling the pores in the facing of the wall.

Another waterproofing device for concrete is to use 1% by weight of alum with the sand and cement and 1% of soft soap with the mixing water. The chemical action set up makes an insoluble compound which practically fills all pores, making an impervious concrete.

The above are only a few of many processes employed. The reader is referred to the advertising pages of engineering or scientific journals for names of dealers in waterproofing materials, with suggestions that literature from those firms be obtained and carefully studied.

No waterproofing scheme, however, will strengthen the concrete, and many methods for waterproofing damage the cement, and this makes the concrete less durable. Certainly, a 1:5 concrete, waterproofed, is not so good and durable as the 1:2 concrete, which it is said to equal in moisture resisting quality.

It is probable, however, that waterproofing may often be wisely done on the face of concrete, or incorporated in the whole body of concrete (or at least in the facing mortar of same), whether made in correct proportions or not. It can also be used wisely in the cement mortar that is used in laying up concrete blocks. In hollow concrete walls made by blocks of two-piece system this can be made to prevent water or frost working through, even though the blocks should be made of a porous mixture.

Blocks may be colored very economically without any harm by means of iron or other pigments which are put up by various manufacturers (Ricketson Mortar Color Co., of Milwaukee, Wis., for instance) in a great variety of shades. It can be economized by using it only in the facing of the blocks, if the method of manufacture permits a facing of different mixture thoroughly united to the rest of the block. Concrete may also be colored at the same time it is waterproofed by some processes, the stone liquid or waterproofing jelly, for instance, being colored.

2. FORMS OF BLOCKS. PATENT RIGHTS AND THEIR VALUE.

When concrete first came into general use, it was probably used mostly in making large blocks, at convenient places, to be used, after becoming thoroughly set, in building large sea walls and other heavy masonry structures. The idea of molding a monolithic wall was a later development. The idea of making a wall hollow for the sake of economy, or for prevention of moisture or frost working through was a still later development. At the present time, practically all concrete block manufacture is designed for making a wall with hollow blocks, with continuous air chambers in the fall, or by making blocks which, though perhaps not themselves hollow, will lay up into a hollow wall.

The steps leading up to the present state of the industry were all patented by their inventors, and the man who desires to go into a concrete building block business will do well to look thoroughly into the patent rights question. Many of these patents bear recent dates, and their holders sell local county or city rights—transferring such rights for so much money—and guaranteeing the exclusive right to manufacture such a block or such a wall in the territory in question. It is certain that many such patent rights are good merely for the machine employed to make the block, and are not broad enough to cover the block of the form made by the machine, or the wall made of the blocks. Anyone purchasing patent rights should bear in mind that patents are not always upheld by law courts; therefore, he should use ordinary business caution to see that the selling company's guarantee is good.

On November 17, 1850, Joseph Gibbs was granted Patent No. 13,071 by the British Government on several improvements in the manufacture of cement and concrete. His patent included the method, now so common, of building solid concrete walls by means of timber forms or lattices on either side. The specification continues:

When it is thought advisable to dispense with the lattices and to make the wall without any part of it being composed of wood, then in such cases, blocks of the size of the stone of which the wall would be composed under ordinary circumstances are to be cast, only these blocks are to be hollow, having only sides and ends, the sides and ends being made about two inches thick.

CONCRETE BLOCKS

No. 80,358,

PATENTED JULY 28, 1868.

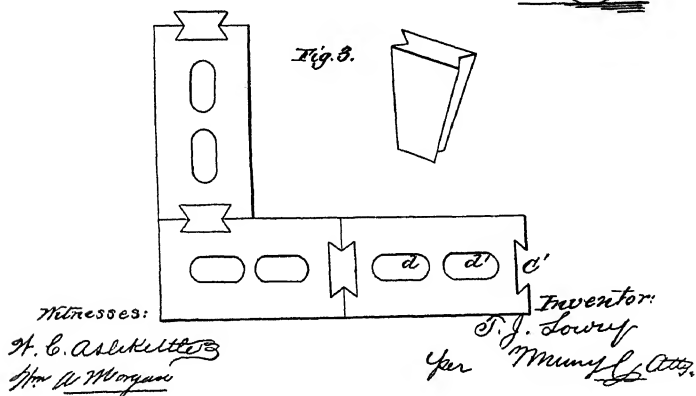
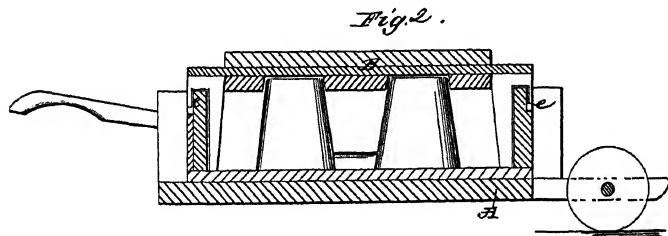
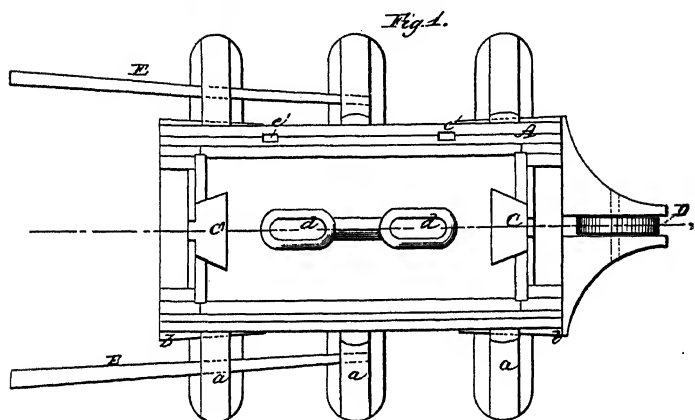
T. J. LOWRY.
MOLD FOR BUILDING BLOCKS.

PLATE I.—Lowry's Patent Mold for Building Blocks, 1850.

After every course of these blocks have been built, the hollows must be filled with concrete like that before described. The blocks being made to break joints with each other, and being filled with cementitious matter, the wall will become one mass of solid artificial stone, so there will be no necessity to put mortar between the blocks to bed them. Instead of the blocks being cast in the shape of hollow parallelograms they may have merely a back and face, such back and face being held together by only as much cement or other material as will keep such back and face in parallelism with each other during the time they are setting (after which the filling must be the same as before). It will be well to wet the blocks before concreting cement is put in, so that they may all unite to form a solid mass of artificial stone.

Having described the second part of my invention, I declare that what I claim in respect thereof is as follows:

First—

Second—

Third—I claim the process of molding artificial stone by putting plastic materials between lattices or other convenient forms, and also the method of casting hollow parallelograms in cement to be afterwards filled up with concrete for artificial stone.

It is evident from this description that the inventor did not intend to use his invention for hollow walls, but it is certain that many walls were built in England and Scotland by both the systems above described in which the builders did not complete the process, but left the wall hollow; and it seems possible that the granting of this patent (which long ago expired) may be construed as invalidating many more recent patents on hollow blocks and hollow walls.

On July 28, 1868,* Thos. J. Lowry was granted U. S. Patent No. 80,358 on a hollow block and wall, the block being almost the exact shape of those made by use of many of the hollow block machines or processes now in use. Plate I. of this paper shows the drawing which accompanied the patent. This patent, of course, long ago expired.

On April 14, 1874, T. B. Rhodes was granted U. S. Patent No. 149,678 on a great variety of forms of hollow building blocks and hollow shingles, of "concrete or other material, which in its plastic condition may be molded into the required form." Plate II. is one of the three sheets of drawings which accompanied the patent. In this patent, no method of molding the blocks is shown or called for, or even suggested, so that a broad interpretation of the patent would be that it granted Mr. Rhodes the exclusive right to make blocks of these forms by any method of molding then known. It may be noted from the date of this patent that it long ago expired.

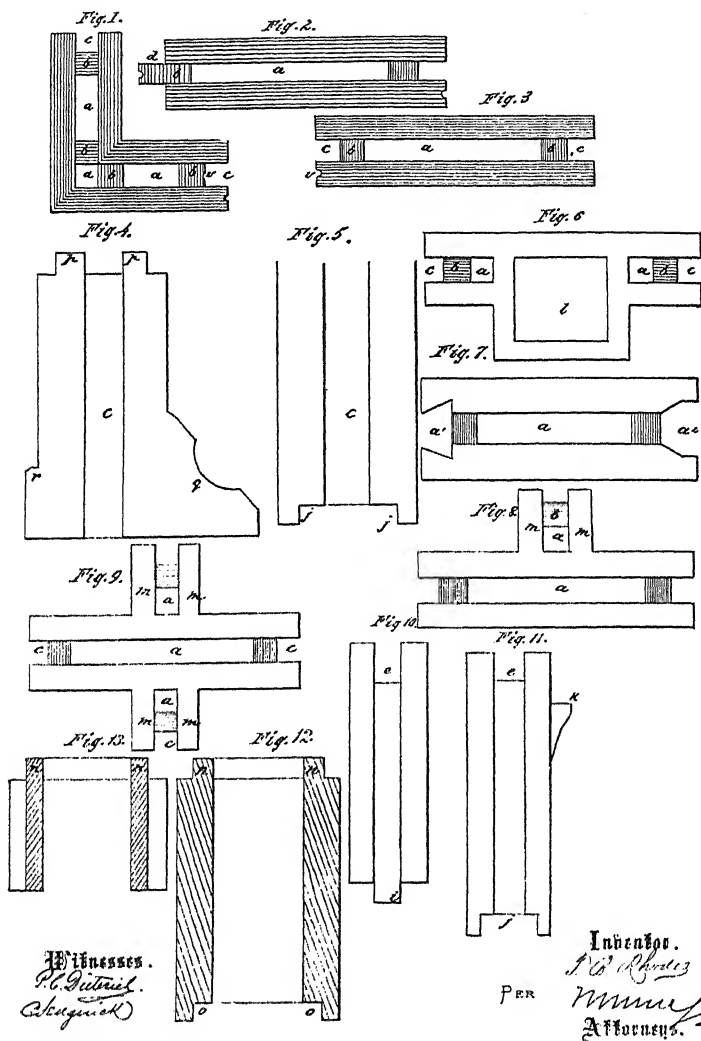
The H. S. Palmer Co., of Washington, D. C., appear to claim in their literature the right to control by virtue of their patents the basic principle of hollow concrete building block machines with

*Since this article was submitted in this competition the writer has discovered a still earlier patent; viz., No. 53,004, granted March 6, 1866, to C. S. Hutchinson on a hollow building block and wall making continuous ver-

T. B. RHODES.
Building-Blocks.

No. 149,678.

Patented April 14, 1874



removable cores and adjustable sides. Their patents also cover certain forms of block. Plate III. (A and B) shows the drawings accompanying Patent No. 674,874. This patent, and others controlled by the same company, if rightfully granted, are evidently being infringed on by the makers and users of a great many other machines. The makers of these other machines and devices are practically unanimous in their claims that the Palmer patents, as far as the block or wall is concerned, are void, and act up to this belief. Consideration of the patent 80,358* to Mr. T. J. Lowry, of the patent No. 149,678 to T. B. Rhodes, and of the patent granted by the British

H. S. PALMER

No. 674,874

Concrete Wall for Building

(No Model.)

(Application filed Mar. 21, 1900.)

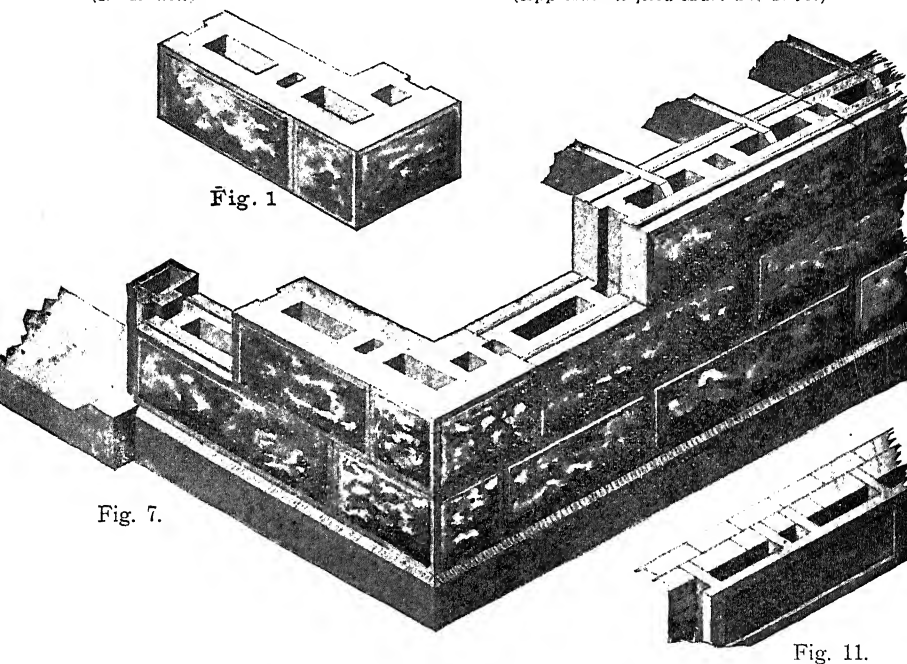


Fig. 1

Fig. 7.

Fig. 11.

PLATE III-A.

Government to Joseph Gibbs in 1850, naturally lead one to question which is right, and all parties interested should insist on a speedy determination of the matter.

To illustrate the trouble that is occurring, and may continually occur, attention is called to the Hayden Block Machine. This machine and whole outfit is sold by its manufacturers† to anyone,

*Also patent No. 53,004 to C. S. Hutchinson.

†Hayden Automatic Block Machine Co., Columbus, O., and 26 Cortlandt St., New York City.

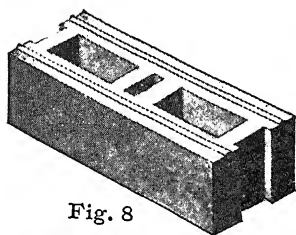


Fig. 8

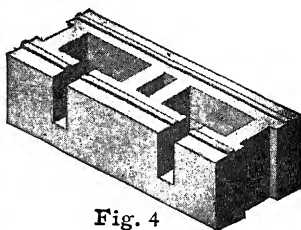


Fig. 4

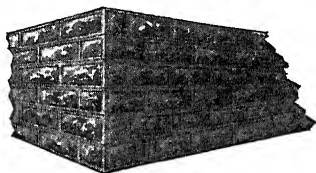


Fig. 2

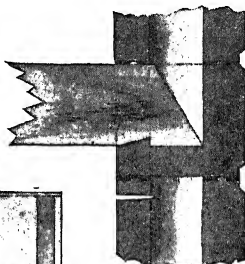


Fig. 6



Fig. 5

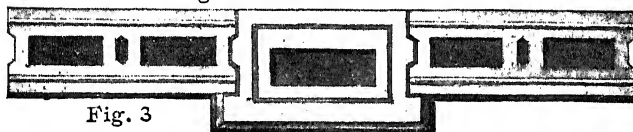


Fig. 3



Fig. 9



Fig. 10

Witnesses:

W. C. COLLIES
WM. GEIGER

Inventor:

HARMON S. PALMER

PLATE III-B. Palmer Patent of 1900.

anywhere, for a definite sum, enough to net a fair machine shop profit. They are willing to give with this outfit a bond for several thousand dollars if desired guaranteeing the purchaser against any patent troubles. The makers of the Hayden Block Machine emphatically deny that the manufacture of the blocks made on their machine infringes any patent in force. Their machine, however, makes blocks almost precisely of the pattern of the Palmer block, though in its construction it is almost entirely dissimilar to the Palmer machine.

This question is a more serious one, on second thought, from the fact that, if the patent holding company should take the question to the court of last resort, and procure a favorable verdict, royalty could be collected from the contractor, or from the owner by the patent holding company.

There are at least two types of block made of width equal to the whole thickness of the wall in which there are no webs that

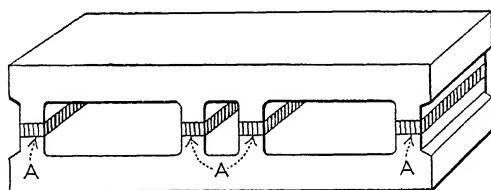


Fig. 1.

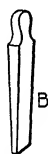


Fig. 2.

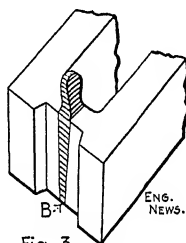


Fig. 3.

PLATE IV. Purdy & Henderson's Plan for Making Waterproof Blocks.

pass directly through the wall; viz., the "Miracle" and the "Blakeslee," both of which are patented. Plates No. VI. and No. VII. show the drawings which accompanied the patents on these forms. These two types, though accomplishing the same purpose, are different in form. One makes a wall with vertical, the other with horizontal air passages. Both of the companies holding these patents have exclusive territorial rights to sell. (Miracle Pressed Stone Co., Minneapolis, Minn., and Blakeslee Concrete Block Machine Co., Columbus, Ohio.)

The first claim in the Blakeslee patent is "A building block wherein there are no continuously solid portions from front to rear." This patent was filed Dec. 19, 1903, and bears the date May 24, 1904, the patent being No. 760,774. The third claim of

the "Miracle" patent covers "A building wall consisting of concrete blocks having two rows of air cavities, the cavities of the one row being opposite and being larger than the intervals or necks between the consecutive cavities of the other row," etc. This is patent No. 730,780, filed Dec. 1, 1902, and issued June 9, 1903.



PLATE V. Comparative Test of Blocks to Show Relative Porosity.

The patent records show that application for a U. S. patent on a multiple air space wall was filed Dec. 4, 1903, by Peter Dierlamm, of Stratford, Canada. This patent, No. 774,835, was granted in November, 1904. The drawing accompanying this patent (Plate VIII.) shows that this patented block is almost exactly the same form as the Miracle block. Application for this patent was filed prior to the application for the Blakeslee patent No. 760,774.

Plate VI., Fig. 3, shows a horizontal section of a portion of a "Miracle" wall. Plate VII., Fig. 10, shows a vertical section of a portion of a "Blakeslee" wall. The writer has added to Fig. 3, Plate VI., three lines marked AA, BB, CC. These lines show how four "Blakeslee" blocks would make one block similar in form to a "Miracle" block turned on end. Practically the same thing would be true of a block of the form patented by Peter Dierlamm.

The "Blakeslee," "Dierlamm," and "Miracle" blocks are improvements on blocks of the "Palmer" type designed to prevent moisture from passing through a wall by doing away with webs passing direct from front to rear. Both the Blakeslee and the Miracle processes use "dry" concrete, the machines being somewhat similar to those used in the Palmer process, which also uses "dry" concrete. Nearly all the competitors of the Palmer Company which makes blocks of forms like or similar to the Palmer blocks also use "dry" concrete. The object gained by using "dry" concrete is rapidity of manufacture, as a block may be removed from the

machine as soon as it is tamped and the next block may be started at once, which could not be done by use of "medium" or "wet" concrete.

No. 730,780.

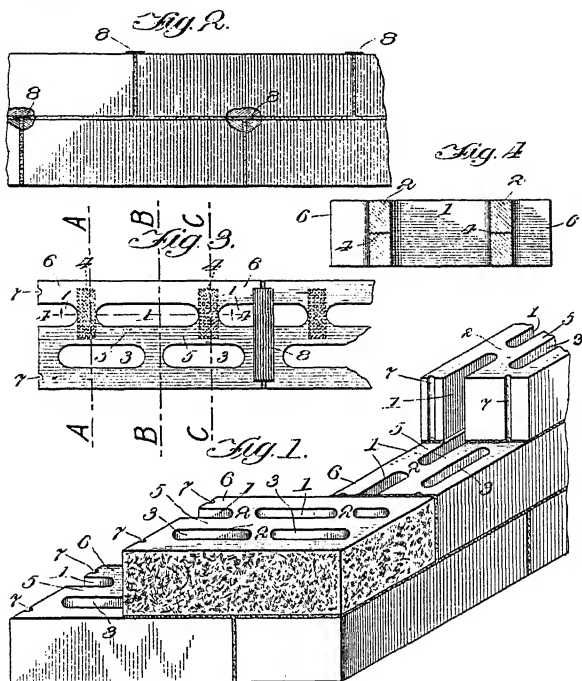
PATENTED JUNE 9, 1903.

O. U. MIRACLE & W. L. DOW.

BUILDING WALL AND CONCRETE BLOCK FOR SAME.

APPLICATION FILED DEC. 1, 1902.

NO MODEL.



Witnesses:
H. P. Gaicher
Fred. B. Fischer

Inventors:
Orville U. Miracle
W. L. Dow
By Buntin Buntin Attorneys

PLATE VI. Miracle and Dow Patent of 1903.

Purdy & Henderson, of New York City and Havana, Cuba, have recently invented a process which will allow the use of "dry" concrete in blocks made on a machine of the Palmer type, and yet make blocks that will not allow the passage of water or frost from front to rear. Plate IV. shows this improvement, which is described as follows:

Fig. 1 on the accompanying drawing shows the block with the improvement AAAA. It shows the position of the improvement in the webs of a hollow block. If the block were solid the improvement AAAA would be continuous, running longitudinally through the entire block, and if it is desired it is to be used continuously in the solid walls of the hollow concrete build

ing block. The partition or stratum represented by AAAA, in Fig. 1, which is impermeable, may be made of a mixture of cement, fine sand, or pulverized stone, or both, and hydrated lime, or other waterproof composition, such as asphalt.

Fig. 2 shows the wedge-shape core B which is placed in the openings in the block machine or mold in which the block is to be made. The block is tamped or poured with the wedge-shaped cores in place. When the block is finished on top, the wedge-shape cores are drawn out and the waterproof mixture, of which the stratum is formed, is poured into the opening, and it becomes homogeneous with the balance of the concrete at once, and the block may be removed as ordinarily and the waterproof stratum or partition will remain in place.

What we claim as new, and what we wish to secure by letters patent is: First, The wedge-shape core used in making the opening in the webs or walls of the hollow concrete blocks or of a solid block for the partition or stratum of waterproof mixture.

Second, The partition or stratum of waterporof material in the webs or walls of the block as shown in the drawings.

(Signed) Purdy & Henderson, Inc., Inventors.

The inventors are using this process largely in Cuba at the present time and, patent being applied for, have no competition

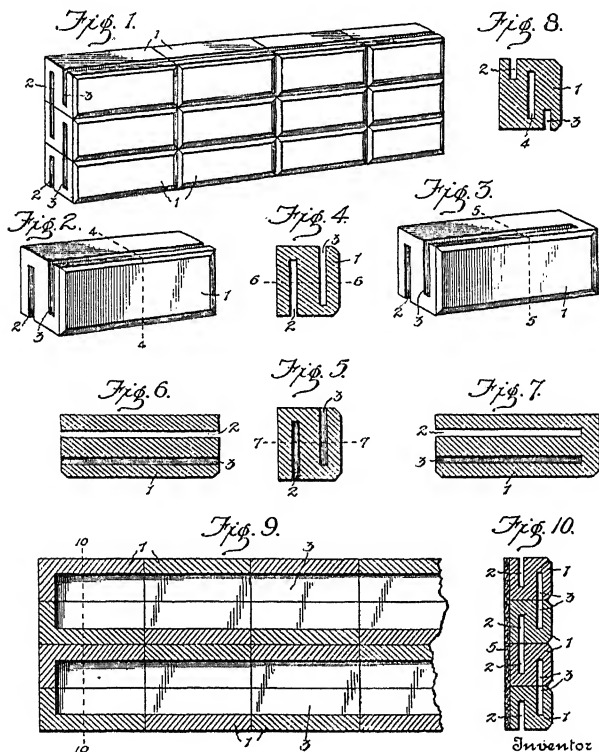
No. 760,774.

PATENTED MAY 24, 1904.

F. W. BLAKESLEE.
BUILDING BLOCK.

APPLICATION FILED DEC. 16, 1903.

NO MODEL



Witnesses
Ralph Shepard
Ralph Shepard

Inventor
F. W. Blakeslee
by Alfred Parker.
Attorneys

there. Patent rights on same will no doubt be for sale locally in this country soon.

Plate V. shows a comparative test of two blocks of the Palmer type. One is entirely of "dry," hand-tamped concrete; the other is of the same material with the insertion by the method described above of a wet mixture of broken stone concrete, no other waterproofing being used. Note that moss is growing freely on the upper surface of the unimproved block, while the improved block allowed no moisture to pass up through to the top. At the time this picture was taken both blocks had been resting in the water side by side for eight months.

This test seems to the writer to be as good a proof as one could wish of the much greater value of a "wet" mixture composed of broken stone, sand, and cement, over a "dry" mixture composed of only sand and cement.

There are on the market at present at least three processes of hollow wall construction which do not use the "dry" concrete; viz., by casting "wet" concrete in metal molds; by mixing "medium" concrete and molding same under pressure by machinery; and by casting "wet" concrete in sand. In all these processes gravel or broken stone may be freely used.

The process of casting "wet" concrete in metal molds is comparatively cheap, one of the chief items of expense being the great number of metal molds required. These are made with collapsible core pieces and of hinged joints, so that, after setting, the block may be removed.

Plate IX. shows the drawing which accompanied the original patent No. 704,606, now owned by the American Hydraulic Stone Co., of Denver, Colorado, on its "two-piece" system of hollow wall construction. This company uses in its machinery "medium" concrete compacted by great pressure in the machine. There are numerous advantages to this system over many others now in use, a few of which are here given.

1. The chance to make the wall, and the individual webs of the wall, any thickness desired, by simple adjustments of machinery.

2. The chance to use $\frac{3}{4}$ -in. or 1-in. gravel or broken stone in the aggregate, thus making a true concrete.

3. The patent rights held by this company are very broad, and, if they will hold, they cover almost any conceivable arrangement of blocks of concrete or other material in which the faces are of separate pieces bonded together in the middle of the wall by T. L. or channel projections extending into the middle of the wall.

4. The method of manufacture adopted by the use of the patented machinery of this company allows the use of sufficient water

CONCRETE BLOCKS

No. 774,835.

PATENTED NOV. 15, 1904.

NO MODEL.

P. DIERLAMM.
BUILDING BLOCK.
APPLICATION FILED DEC. 4, 1903.

Fig. 1.

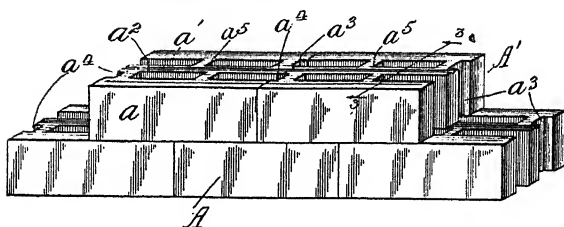


Fig. 2

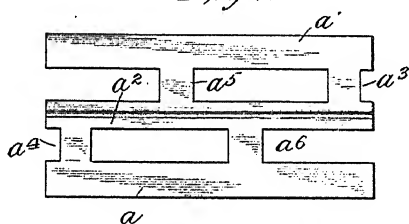
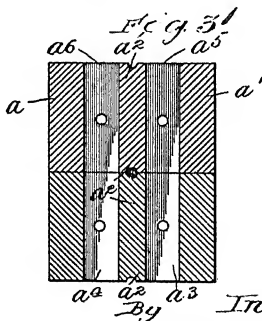


Fig. 3!



Witnesses:
Ray White.
Harry R. White

By ^{a2} ^{a3} *Inventor:*
Peter Nierlamm,
Charles W. Hill Atty.

to make a "medium" mixture of concrete. The following claims deserve consideration:

*It is indeed strange, after exhaustive tests on general concrete work have so thoroughly demonstrated the ineffectiveness of a "dry" mixture, that so many should undertake to manufacture concrete blocks without sufficient water to excite such hydraulicity as will secure that thorough crystallization of the silicates of lime and alumina, without which the bonding of the aggregates is imperfect and the concrete easily crumbled. Indeed, it would seem that, eliminating the question of chemical activity, the mere physical problem of combining materials to form the agglomerate should convince the practical man that a "dry" mixture is not feasible, because if the cement be not reduced to a solution it can neither fill the voids nor afford necessary cohesiveness by thoroughly coating the sand and aggregate.

In considering the methods of manufacture, we notice that the system of applying a heavy uniform, and almost instantaneous pressure is radically different from the customary method of tamping "dry" concrete. It is here that the concrete block manufacturer has a decided advantage over monolithic construction, as the application of a pressure at once adequate and uniform eliminates squashing and sub-pressure, and secures a density and freedom from porosity which a "dry" mixture cannot produce; moreover, the application of such pressure on the face of the block, where the greatest density is required, secures a face practically impervious to moisture and free from the accumulation of soot and dust which has so often rendered cement houses unsightly.

The speed of operation under this system is merely limited by the time taken to fill the molds. As the mold runs into and out of the press on an iron track, and the pressure is made by one downward motion of the levers, the operation requires less than four seconds exclusive of filling the mold. Under ordinary conditions, it has been found that four men operating the press and molds (the mixture being supplied to them) will turn out enough blocks to make 1,000 square feet of wall in ten hours; this rate can be materially increased by the arrangement of elevated bins, overhead mixers, chutes and cut-off boxes to feed the molds automatically.

In marked contrast with other systems of block making, this one seems to have been designed with especial view to the application of a rich face at a minimum cost. By striking out a quarter or half-inch of the coarse concrete before pressing the block, filling the space thus created with a mixture of suitable fineness and then applying the pressure, the face is so thoroughly incorporated with the body of the block that no line of cleavage remains, and no instance has ever been reported of a face thus applied separating from the main block—it becomes a part of the block itself.

In the construction of walls, the well-known principle of the header bond is employed at intervals of 9 to 12 ins., thus insuring a resistance to thrust and lateral stress which cannot be expected in construction where blocks are merely laid end to end without transverse bond.

5. The continuity of both horizontal and vertical air spaces. One of the most ingenious devices of this system of laying walls is the continuous horizontal air space which extends throughout the wall, making in effect two walls tied by the overlapping of webs in alternate courses; thus a very thorough insulation is secured, making a concrete wall construction impenetrable by moisture.

6. The securing of a very large percentage of air space. By the use of pressure as above outlined, combined with the use of true concrete and adequate moisture, this company has been able to increase the air space in a wall from an average of 30% under the one-piece systems to an average of 55% without any sacrifice of strength. Thus a great saving is made in the amount and cost of material and a corresponding decrease in the weight of walls, while the increased air space saves 25% of heating bills, renders a building cooler in the summer and affords walls practically dead as to sound.

*Quoted from dictation by H. H. Rice, Secy. of American Hydraulic Stone Co., Denver, Colo.

7. The ability, on account of the through bond, to construct a wall of any length without providing expansion joints. Long walls of "one-piece" blocks have given trouble where such joints were not provided.

No. 704,606.

Patented July 15, 1902.

C. F. WHITTLESEY.
BUILDING BLOCK AND WALL.

(No Model.)

Fig. 1.

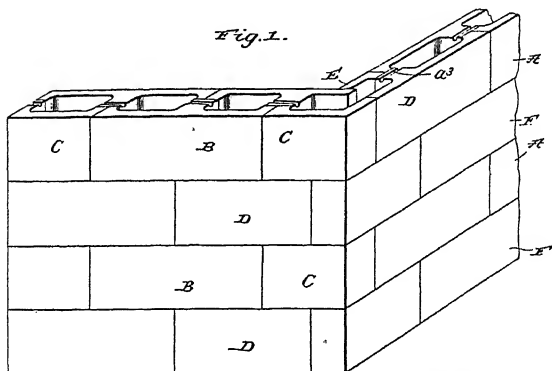


Fig. 2.

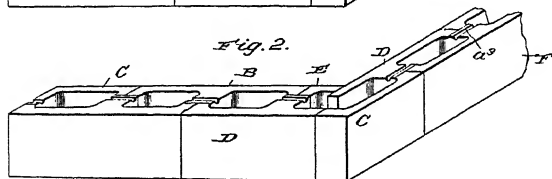


Fig. 3.

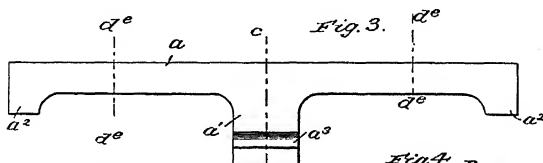


Fig. 5.

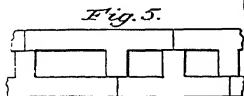
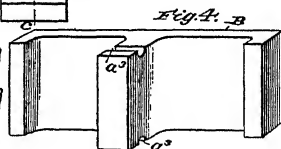


Fig. 4.



Witnesses
[Signature]
R. C. Healy

Inventor
By *[Signature]*
James J. Healy, Attorney

PLATE IX. Whittlesey Patent of 1902. Owned by American Hydraulic Stone Company.

8. The greater ability to use the inside surface of an outside wall built by this process for a surface on which to plaster without furring and lathing. Those blocks to be used for inside face

of the wall are left rough, without the application of a smooth finish, so that an excellent bond with the plaster is assured, and the wall being in two pieces can be kept in alignment very easily so as to insure a uniform thickness of plastering. Plate X. shows how continuous horizontal and vertical spaces throughout the wall are obtained.

The process of casting wet concrete in sand is very adaptable in buildings where the architecture requires arch stones, plain or fluted columns, ornamental caps and sills to windows or doors, ornamental water tables and cornices, etc.

Patents Nos. 583,515, 699,587, 699,588, and 624,563, granted to C. W. Stevens, are held by the Stevens Cast Stone Co., of Chicago, on this process. This company, in applying for a patent in Germany, was told that it was not believed possible to successfully cast concrete in sand, so men were sent to Germany to demonstrate the process. The patent was granted.

These patents cover broadly the process of casting any shape, more particularly hollow shapes, of concrete in sand molds or molds partly of sand and partly of other materials. These molds are, in many cases, substantially the same as for casting molten metal, and the same quality of molding sand is used. It is questioned by many whether these patents will hold, and there has been much concrete block work done by this method where patent rights from the Stevens Cast Stone Co. were not secured. It is certain that the process of casting any molten metal in sand molds would not be, at this late date, a patentable process. The Aberthaw Construction Co., of Boston, Massachusetts, cast all of the concrete steps for the Harvard Stadium in sand molds, by use of patent rights granted by J. C. McClennahan (Patent No. 711,436). This process, in practice, is substantially the same as that employed by the Stevens Cast Stone Co., the McClennahan patent using in the sand or other mold a "hardening chemical solution." In practice, the writer has been informed, a small proportion of sulphuric acid is added to the water used in compacting the sand molds.

In Cuba this process seems to be open to competition to any one who desires to use it, without regard to patents.* To the writer's mind, a local manufacturer should use some process that will accomplish the results of "casting in sand" to some extent (however he establishes his right to do so) in order to be able to take any work open to brick, stone or concrete. A man could, for instance, acquire the local county or city rights for the American Hydraulic Stone Co.'s process, which he could use for all the main body walls, etc., and then could use "cast in sand" concrete for his

*The writer has since been informed that Purdy & Henderson control the Stevens patents for Cuba, and regard other manufacturers as infringers.

lintels, sills, water tables, cornices, columns, arches, or any curved bow windows required, using reinforcement of steel rods or wire

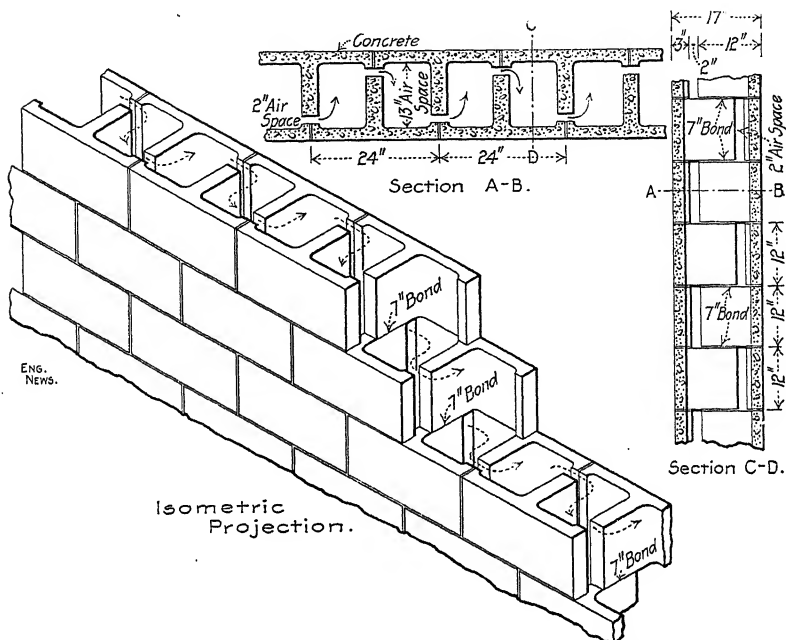


PLATE X. Illustrating Continuous Horizontal Air Space in Wall Built on American Hydraulic Stone Co.'s System.

cloth, if desired, and be much better able to compete with stone or brick work.

The literature of the Mandt Cement Block Co., Stoughton, Wis., illustrates a novel multiple air space wall. This is a two-piece wall, as may be seen by the illustration, Plate XI. This is described quite thoroughly in "Municipal Engineering," July, 1905.

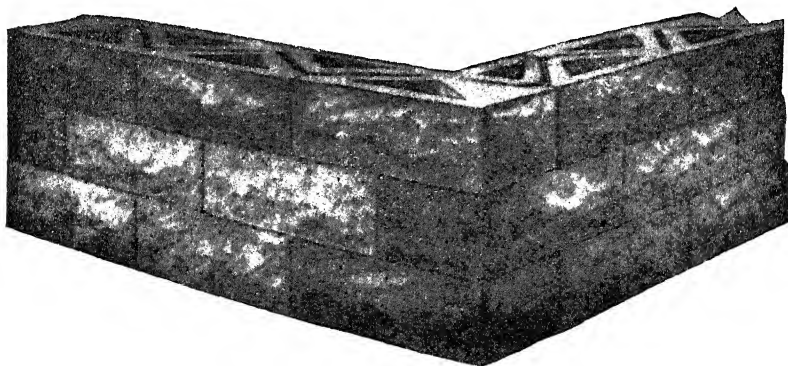


PLATE XI. Multiple Air Space Wall of the Mandt Cement Block Co.

Application for patent on this block and wall was filed May 10, 1905, and has not yet been granted. The bond is the same as that of the American Hydraulic Stone Co.'s two-piece system. (See Plate X.)

No. 776,409.

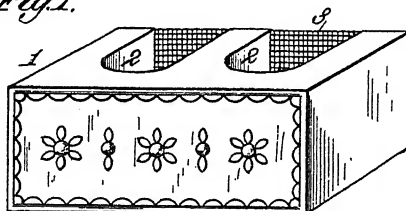
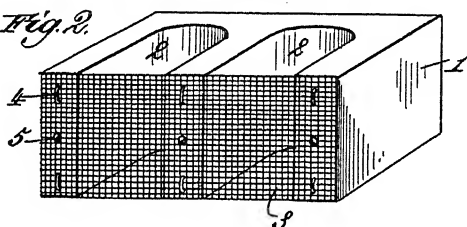
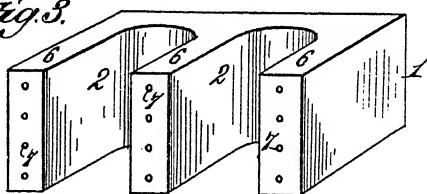
PATENTED NOV. 29, 1904.

NO MODEL

A. C. MATHER & M. F. BOWEN.

BUILDING BLOCK.

APPLICATION FILED JUNE 23, 1903.

Fig. 1.*Fig. 2.**Fig. 3.*

Witnesses,
Alfred Everett
W. C. Ruff

Inventors,
Alonso C. Mather
Millard F. Bowen
 By *James L. Norris*
Att'y

PLATE XII. Mather and Bowen Patent. (Owned by American Hydraulic Stone Co.)

Attention is called to Patent No. 776,409 to A. C. Mather and M. F. Bowen. Plate XII. shows the plan of this block, which when laid up becomes a well-bonded wall with a hollow back, to the channel projections, on each block of which wire lath is attached for

plastering. This form of block is one of the forms used by the American Hydraulic Stone Co. in its patented "two-piece" wall, and could easily be made of impervious broken stone concrete on the machines of that company. The writer has seen no advertisements of any company using this block, but it should become a much-used form of wall.

The literature of the Queen City Brick Machine Co., Traverse City, Michigan, illustrates a process of making ordinary sized bricks of concrete composed of sand and cement, by pressure, by use of their patented machinery (Patent 761,886). These bricks are all of the same size and may be made with ornamental faces, etc. Such concrete bricks should find a ready market, if the claims of the machine manufacturing company are not exaggerated.

In closing the patent rights question, the writer would refer to the list of patent numbers, etc., below, and would suggest that the prospective manufacturer of concrete blocks should read copies of these patents. These may be purchased from the U. S. Patent Office for five cents per copy.

The reader could examine the "Official Gazette of the United States Patent Office" for this purpose. This publication is issued weekly (\$5 per year), and gives a resume of all patents as issued. A complete index is issued annually. Every volume of this publication is on the shelves of the Astor Library, New York City, or in any large public library. This library also has on its shelves bound volumes of the complete drawings and specifications of all patents issued.

In 1904 alone about sixty patents bearing on the subject of "building blocks" were granted. Even a casual observer can see that many patents conflict.

Below is a list giving some of the more important patents:

IMPORTANT PATENTS BEARING ON THE SUBJECT OF CONCRETE BLOCKS.

	Patent No.—		Year.
Joseph Gibbs	13,071 (British Govmt.)		1850
T. J. Lowry	80,358		1868
Theodore Hyatt	142,475		1873
T. B. Rhodes	149,678		1874
H. S. Palmer Co., Washington, D. C.	375,377	623,086	1887
	674,874	727,427	
	727,428	759,010	1904
	730,780		
Miracle Prsd. Stone Co., Minneapolis, Minn.			1903
Blakeslee Concrete Block Machine Co., Columbus, Ohio		760,774	1904
Peter Dierlamm		744,835	1904
A. C. Mather and M. F. Bowen		776,409	1904
J. C. McClennahan		698,727	1902
		711,436	
Stevens Cast Stone Co., Chicago, Ill.	583,515	624,563	1897
	699,587	699,588	
	704,606	733,928	1902
	742,096	743,391	
	749,796	767,398	
	767,413	767,414	
	769,601	769,655	1902
	769,656	769,816	
Am. Hydraulic Stone Co., Denver, Colo.	771,816	772,032	1905
	773,630	773,647	
	775,347		

In purchasing patent rights one should, of course, be able to trace the right to deal in them from the selling company back to the patentee. The laws and court decisions relative to the common use of a patent by the employers of the man who developed the patent, and by the inventor himself, should also be considered, as he might purchase exclusive local rights of the one party only to encounter competition from the other.

3. COST.

(1) Establishing an Industry.

The amount of capital necessary to purchase a machine or outfit sufficient to make the equivalent of from 5,000 to 20,000 brick per day is in no case more than from \$200 to \$600. To this must be added credit or capital sufficient to obtain supplies, rent of land, use of teams, etc., to suit local conditions.

If the form of block, or the whole process, is patented, an additional sum must be paid for patent rights for the local use of the process. The companies holding these rights are all ready to sell exclusive local rights at rates ranging from \$5 to \$50 per thousand population. Sometimes a part of this payment may be made as a royalty on wall as made until whole contract amount is paid.

It is usually best to establish the industry near the source of supply of broken stone or sand, or near railroad yard or wharf where such material may be unloaded. Inasmuch as any considerable business will require an extensive plant of tram cars and sprinkler system to care for the blocks, etc., after being made, it will usually be best to make the blocks at a central yard and transport by team to the building site after they are cured and ready for the wall. The machinery is usually so light and portable, however, that for a large building it often pays to set it up at the site, and if this is done, the blocks may be put into the wall sooner after manufacture than would be the case if necessary to team them.

The advertising pages of "Engineering News," "The Cement Age," "Cement and Engineering News," "Municipal Engineering," and many other scientific journals contain advertisements of those firms which have been mentioned, as well as of many others. "Municipal Engineering" (No. 1 Broadway, New York), July, 1905 (\$0.25 per copy), contains advertisements of 58 companies in the United States which make machinery or molds for the manufacture of concrete building blocks, or associated products. All of these companies have literature concerning their processes for distribution, and the writer would suggest that much of this literature deserves perusal, and the advertisements themselves are well worth reading. In corresponding with any of these firms, he

would suggest also that special emphasis be laid on inquiries concerning patent rights, and concerning the ingredients which it is possible to use in the concrete, including the proportion of water, in order to determine probability of patent infringement legal troubles, and probable quality of product to be obtained by the process.

(2) Cost of Product.

The cost of any concrete building block depends on two things: The cost of the labor to mix the ingredients and that required to put the mixture through the machine or process. Ordinary broken stone concrete, mixed in proper proportions, in large masses, costs in place from \$4 to \$8 per cu. yd., depending on local cost of ingredients, and on the shape and size of the masses put together.

To put such concrete through the American Hydraulic Stone Company's machinery costs little more than the ordinary process of putting it into wooden forms, with the cost of form work included in the latter. Thus, in a wall made by this process with 50 per cent. hollow space, the actual cost to the manufacturer for the blocks is just about 50 per cent. of what the cost would be to build a solid concrete wall of the same outside dimensions, of same grade of concrete. The cost of labor of laying up the wall with these blocks is small, and so the total cost of the hollow wall is not much more than half of the cost of the solid wall. The ordinary manufacturer of these blocks makes a handsome profit on them at \$0.15 or \$0.18 per sq. ft. of wall, as the total cost may be as low as 6 cts. or 8 cts. for correctly made concrete. The actual cost of a 13-in. wall has been in some cases as low as 10 cts. or 11 cts. per sq. ft.

The cost of casting concrete blocks in sand is much greater, as the labor item is so much larger, the molds being set up anew for each casting, and labor of molding being comparatively high-priced. In Havana, Cuba, Purdy & Henderson, and J. B. Clow & Son have built a great deal of "cast in sand" hollow concrete block wall at from \$5 to \$6.50 per square meter (\$0.46 to \$0.60 per sq. ft.)

The process of casting the blocks by pouring wet concrete in metal molds is cheaper than by casting in sand. The Stevens Cast Stone Co., of Chicago, use this method for the straightaway work on many of their buildings, using the "cast in sand" method for only the ornamental or peculiar shaped blocks required by the architecture, but using the same "wet" mixture of broken stone concrete throughout. This process is also used by the K. Dykema Co., Battle Creek, Mich.; The Electrical Concrete Post & Stone Co., Lake City, Ia., and several other companies. For the same grade of concrete this process makes more expensive walls than the "medium" concrete process of the American Hydraulic Stone Co., on account of the greater amount of outfit necessary.

Any concrete block machines on the market which use the "dry" tamped process make blocks at prices which vary greatly according to the grade of the mixture employed (\$0.15 to \$0.50 per sq. ft. of wall). The tendency of this process is to use too little cement in order to keep the cost down, as it is possible to use only sand with the cement. Blocks made in correct proportions by this process would cost nearly as much as, or more than, concrete blocks of broken stone, sand and cement, made by the "cast in sand" process.

(3) COMPARATIVE COST OF BUILDINGS OF CONCRETE AND OTHER MATERIALS.

The literature of nearly all of the manufacturers of concrete block machinery contains statements of comparative cost of walls made of their product, and of ordinary brick, stone and wood. A careful perusal of this literature, or an investigation of workmanship, would show that many of these comparisons are overdrawn, or that, in order to make so cheap a wall as described, a poor mixture of concrete was used, and that the labor employed was not of the highest class.

In our large cities, labor unions control the building trades, but, as far as is known to the writer, neither union masons nor union bricklayers have as yet refused to lay a wall of concrete blocks, though these blocks were made by non-union labor. Trouble on this score is probably in store, however, if it ever assumes large proportions. The above mentioned unions have close working agreements with the stone cutters' union, the hod-carriers' union, etc. Unions of concrete workers demanding standard wages of the hod-carriers' union have already been formed, and if these unions become powerful, the item of labor will be increased, as the union bricklayers and masons who lay the wall will undoubtedly insist on having the concrete blocks made by union laborers. At the present time brick and stone masonry walls are built entirely by union labor from the brickyard and the quarry to the finished wall, and ultimately brick, stone and concrete work will all be on the same status in this respect, which is not the case at present.

It is certain, however, that concrete blocks are cheaper than cut stone, of the same durability, and much more adaptable, and for a hollow wall, concrete blocks cannot be successfully competed with by brick or stone. It is customary for concrete block machinery companies to compare the cost of the hollow wall of their product with a solid brick wall of same dimensions. It should also be remembered that the hollow concrete wall—if built by any moisture-proof process—does not need to have furring strips fastened to the inside for lathing and plastering. On a brick wall this furring and lathing are necessary, and so the comparison is still more in

favor of the hollow concrete block wall. Moreover, the hollow concrete wall, of same size and strength as the solid brick wall, weighs only 50 per cent. to 75 per cent. as much as the latter, so money may be saved on the foundation, if on yielding soil.

In general, at the prevailing price of materials, building walls may be built of correctly made concrete blocks for from 40 per cent. to 75 per cent. of the cost of brick walls, or from 25 per cent. to 50 per cent. of the cost of cut stone or fancy brick. In fact, by some processes a house may be constructed of this material for the cost of a good frame house, and the owner has the advantage of a non-burnable construction as well as of a much warmer building.

It should be noted, however, that the process, comparatively new in this country of making sand-lime brick may be destined to reduce the cost of brick walls to about 60 per cent. of their present cost. This process has been in use in Germany for many years. The ease with which bricks of a perfectly uniform size are turned out at a cost to the manufacturer of from \$3 to \$5 per M. renders them formidable competitors with any other building material. The reader is referred to "American Sand-Lime Brick Co.," 1307 Great Northern Building, Chicago, Ill., for data relative to this process. The Paragon Plaster Co., of Syracuse, N. Y., are successful manufacturers of these brick, as well as of the American Hydraulic Stone Company's "two piece" system of concrete blocks.

The process of "casting in sand" will successfully compete with cut stone or terra cotta for ornamental cornices, columns, balustrades, etc., for all places except perhaps points very near to the quarries or terra cotta works. For the same, or equally good appearance, and the same durability, the "cast in sand" process should not cost more than 60 per cent. of the others, while from the standpoint of fire-resisting qualities, there is no comparison, as the concrete would pass without damage a fire test under which cut stone or terra cotta would crumble.

A further comparison might be made by considering hollow walls built up of two separate walls of brick bonded together by metal strips, but to make a good and permanent wall by this method requires a very good metal. Galvanized iron, or copper strips should be used, and even these will sometimes rust through, so that the life of such a wall is not to be considered as great as one entirely of concrete materials.

Brick walls are often built in this manner, sometimes using an occasional "header" brick for the bond instead of metal strips. The cost of a hollow concrete wall will usually not be much less than a brick wall of same outside dimensions, built in this manner, but it will be stronger on account of the more thorough bond.

Under present conditions, it is certain that hollow concrete

wall construction is cheaper than an equally good wall of other materials. This because of the cheapness of crushed rock and sand, in nearly every locality, and the abundance of good cement mills all over the country. For brickwork, stone or terra cotta, proximity to the brickyard quarries plays such an important part, rendering the cost of construction at any considerable distance from these places very great on account of freight charges.

4. ASSOCIATED INDUSTRIES.

Fence posts, telegraph poles, flag stones, roofing slabs, sewer pipes, piles, solid concrete brick of ordinary brick size, etc., are made successfully of concrete. In any locality there is also a great deal of concrete work in cement sidewalks, concrete floors, concrete roofing and basement paving, concrete steps, etc., that is constantly open to contractors.

A concrete block manufacturer could, in almost any locality, carry on some, or all, of these other lines of work to good advantage. He would also find in many places a good chance to engage in a mercantile business in cement, sand, crushed rock, etc. Such a business might enable him to purchase his own supplies in larger quantities, and hence on better terms.

5. ENGINEERING AND ARCHITECTURAL CONSIDERATIONS.

The concrete block business is not growing as it should. This is largely due to the objections raised by civil engineers and architects. The civil engineer argues that the ingredients in the concrete are not the proper ones, that too little water is used in mixing to make the block a success, and that the wall as built needs to be provided with expansion joints in spite of the bonding. The architect argues that, in spite of the claims to the contrary, the walls will be wet, and moisture will work through and spoil the decorations inside where plastering is done directly on the block; that the wall as made looks too artificial; that, if made of "rock faced" blocks, the patterns adopted are too much alike, and there are no sharp corners as in cut stone; that this makes the wall look as though it were faced with galvanized iron, stamped to imitate rock faced blocks, and then painted with a sand paint or cement grout; that in any case a concrete wall cannot be made to look like cut stone work; that the concrete presents such a poor appearance when wet, etc.

It is possible, however, to make concrete block buildings not subject to these objections. Purdy & Henderson, of Cuba, and the Stevens Cast Stone Co., in the United States, have erected buildings by the "cast in sand" process that do look like cut stone. The same is true of other processes. The poor appearance of wet concrete may be entirely obviated by choosing the sand and broken

stone carefully. Clear white sand and crushed rock, with no iron or other coloring matter contained, are procurable, and if used give good results.

The reason for the necessity of providing expansion joints in a long wall of concrete blocks is that the wall is not bonded thoroughly enough. This defect is obviated in the best concrete block work.



PLATE XIV. Miramar Hotel, Havana, Cuba. Built by Concrete Blocks by Purdy & Henders

The engineering and architectural authorities will be convinced by good results, and good results may be obtained. These professions are conservative. Therefore, great care and good workmanship must be used by the manufacturers of machinery, and of the blocks, to get their unqualified indorsement, without which it will never become an important industry.

6. SUCCESS SO FAR ACHIEVED IN THE INDUSTRY.

From an artistic standpoint, the best success in the industry has so far been achieved by means of the process of "casting in sand." In Havana, Cuba, this process has been extensively used. Plates XIII. and XIV. are photographs of "The Royal Bank of Canada" building, and the "Miramar" hotel building, both built by Purdy & Henderson, of sand-molded blocks, except the flat portions

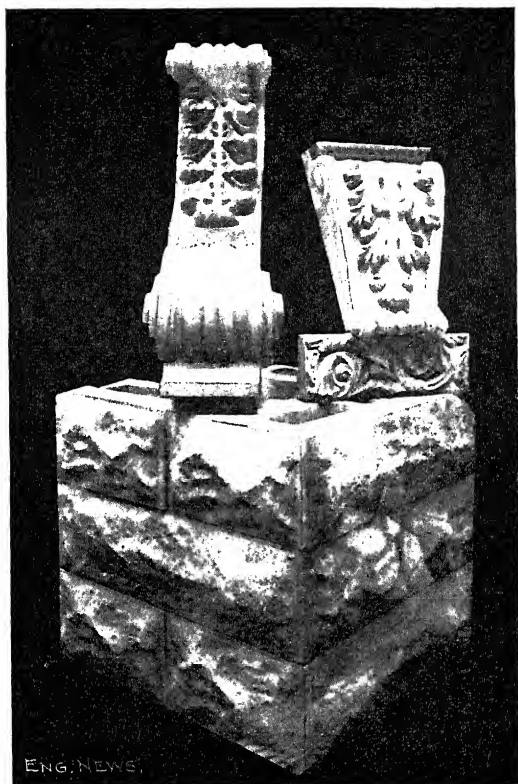


PLATE XV. Concrete Blocks Cast in Sand at Havana.

of the wall near the second story windows in the Miramar, which are "dry" tamped blocks of the "Palmer" type. For reasons noted above, these buildings were quite expensive. Plate XV. shows a group of "cast in sand" blocks from Havana, and Plate XVI. shows a residence under construction.

In Cuba the ordinary "dry" hand-tamped block construction of the "Palmer" type has been largely discarded after having a good trial, as the slanting rain of the rainy season put moisture through walls built of such blocks in a few hours, and the firms now put

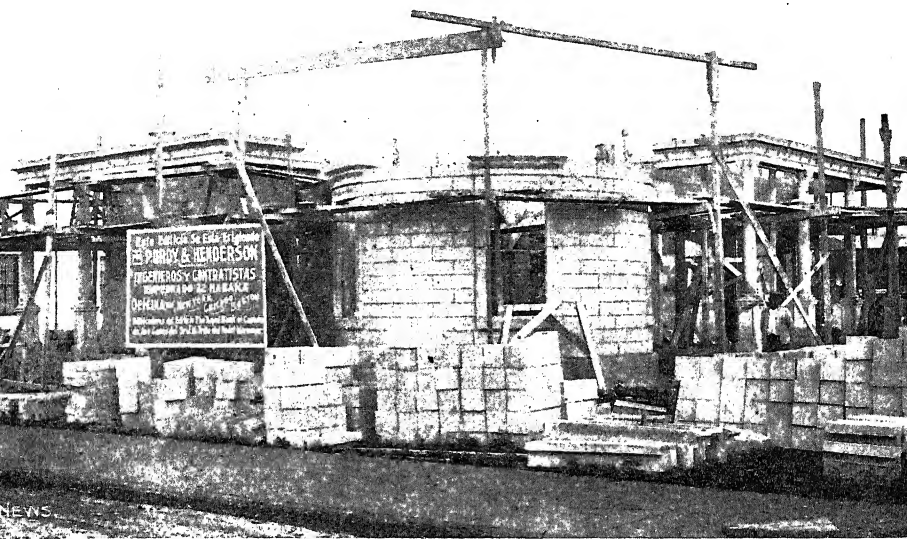


PLATE XVI. Havana Residence Under Construction of Concrete Blocks.

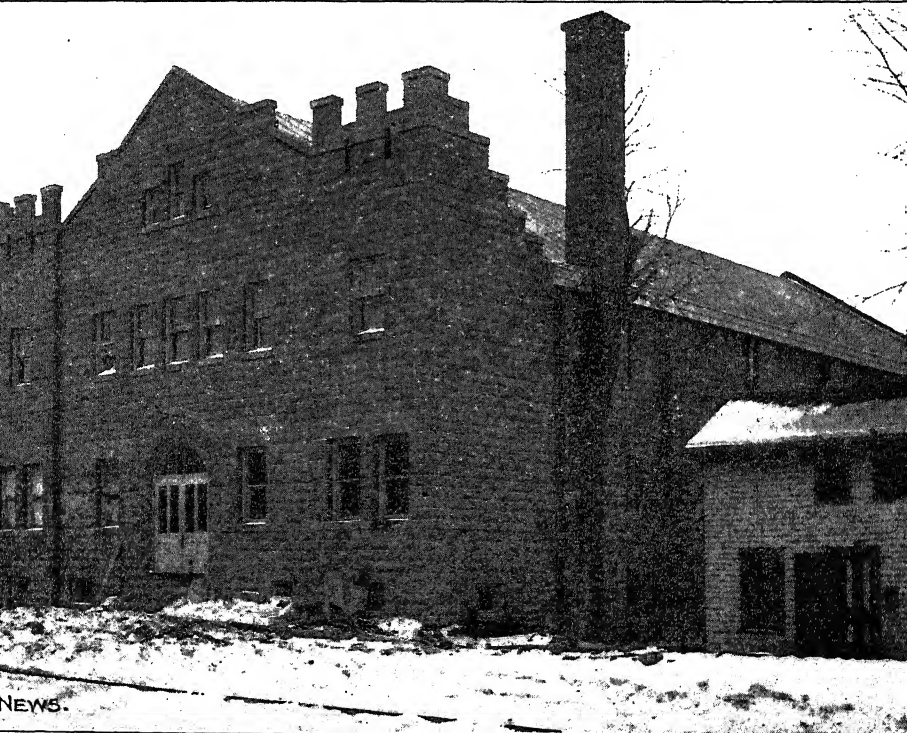


PLATE XVII. New Armory Building, Ames, Iowa. Built of Miracle Concrete Blocks.

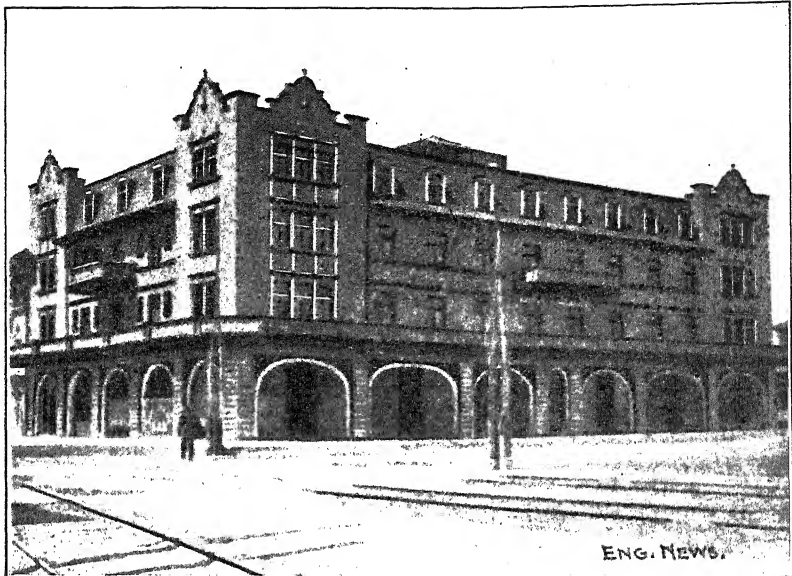


PLATE XVIII. Hotel Angelus, El Paso, Texas.
Built of American Hydraulic Stone Co.'s Concrete Blocks.

ting up buildings of concrete blocks use either "cast in sand" blocks or "dry" tamped blocks made impervious by the new invention of Purdy & Henderson described and illustrated above.

Plate XVII. shows the new armory building at Ames, Iowa,

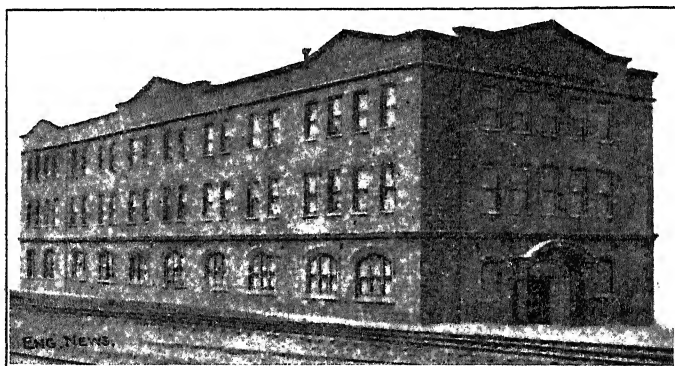


PLATE XIX. Office Building of National Electric Co., Milwaukee, Wis.
Built of American Hydraulic Stone Co.'s Concrete Blocks.

built of "Miracle" blocks. This is a very handsome building and a credit to the Miracle Pressed Stone Company, Minneapolis, Minnesota, whose product makes a wall practically free (as a whole)



PLATE XX. Portion of Wall of Residence Built of "Normandin" Blocks.

from moisture on account of the "double air space" obtained in the wall. The Miracle Pressed Stone Company have granted their local patent rights to a great number of block manufacturing plants in the United States and Canada, and their testimonials from users from all latitudes show good protection from moisture, frost or temperature changes.

Plate XVIII. shows the Hotel Angelus, El Paso, Texas, and Plate XIX. shows the office building of the National Electric Company at Milwaukee, Wisconsin, built of the blocks of the American Hydraulic Stone Company. In this building these blocks have also been used for inside work.

The Naugatuck Chemical Company, 25 Broad Street, New York City, have recently erected a large building at Naugatuck, Conn., of these American Hydraulic Stone Company blocks, of which they are justly proud. This building is said to have cost 25 per cent. less than a common brick building would have cost, and a much better, and better looking building is the result.

Plate XX. is a photograph of a portion of a residence of Normandin blocks (Cement Machinery Company, Jackson, Michigan), showing a good imitation of cut stone.

There has been much very unsatisfactory work in concrete building blocks. Most of this is traceable to the greed of the building block maker who, in order to reduce the cost and increase his profits has used poor concrete. The writer is well acquainted with a building built of "dry" tamped hollow blocks of the "Palmer" or "Normandin" type in which plastering on the inside of the walls was done directly on the blocks. The maker of the blocks stated that the hollow spaces insured dryness. The building is a very damp one on account of the porous nature of the concrete, both on account of being made a "dry" mixture, and on account of a too small proportion of cement in the concrete. Such a failure has given the concrete block business a set-back in that locality in the very beginning.

It must be remembered that there can be as much difference in imperviousness between a concrete block wall made of true broken stone concrete in "medium" or "wet" mixture, and a wall made of "dry" hand-tamped standard cement blocks, as there is between a vitrified paving brick and a common soft brick.

7. ADVANTAGES POSSESSED BY AN ENGINEER OR ARCHITECT OVER OTHERS IN HANDLING A SUCCESSFUL BUSINESS.

In first-class cut stone or terra cotta work, such block is made to size and shape from the plans made by the engineer or architect. In successful concrete block manufacture, each block must also be to size and shape from the plans, otherwise the resulting wall will not present the best appearance. The writer has seen concrete block walls in which joints in the successive courses of the wall were not broken, also walls in which the blocks have been cut by stone-cutters' tools after manufacture, simply because of lack of plans and proper supervision for the laborers employed in making the blocks. The reader is referred to an article in "Municipal Engineering," May, 1904, which illustrates this point.

An engineer or architect who, by education and training, is perfectly capable of making plans and laying out, or directing the laying out, of such work, and who is capable also of directing a business will have great advantage over a man who has no such training, and who therefore tries to do without such ability, or, is forced to hire it. The partnership of a hard-headed business man and an engineer or architect would have its advantages. An engineer will usually have an advantage also in being better qualified to make or supervise tests of materials, etc.

The writer has had occasion above to refer to the work of Purdy & Henderson in Cuba. The success of this firm in concrete building block construction has undoubtedly been largely due to the engineering and architectural ability at its disposal.

The engineer and the architect are much more familiar with matter pertaining to the strength of materials, and are much more apt to insist on good and thorough workmanship in their work than competitors without their training.

CONCLUSION.

It has been said that this is the "Age of Concrete." Cement manufacturers no sooner get their mills built than they are working overtime to fill orders. The growth of the cement industry is enormous, and shows no signs of ceasing. The demand for concrete instead of heavy masonry for bridge work; for reinforced concrete instead of structural steel and brick walls for sky-scrapers, or industrial establishments; instead of brick or hollow tile and structural steel beams for floors; instead of brick or stone for dams, sewers, aqueducts, etc., is a steadily growing one. Now comes the demand for concrete block walls for buildings instead of brick, stone or timber.

A concrete block business if founded on correct business principles as outlined in this article is almost sure to succeed. It is already an assured success in many places.

A business of erecting buildings of concrete building blocks with reinforced concrete floors and roofs is sure to be a popular one before very long. Many such buildings are now in use.

Not the least important consideration in concrete work is its great safety in case of fire. It has been shown that concrete is one of the very best materials of construction to resist fire. In the great Baltimore fire the buildings not destroyed were nearly all of concrete.

In this connection it is well to divide concrete into classes. Concrete walls made by any process giving a porous wall which will absorb moisture, will not withstand fire as well as concrete so compact that no moisture can be contained. In the one case the wall as a whole, on account of air space, double air space, introduction of water-proofing strata, etc., might be slow to allow moisture to pass entirely through the wall, but in case of fire, the confined moisture, previously absorbed, may become steam and crumble the wall. The writer would refer, in this connection, to an article by Noyes F. Palmer, in *Engineering News*, July 13, 1905.

In general, however, the concrete building will prosper largely on account of the growing demand by owners of buildings that they shall have safety from fire to themselves, their families, or their business, and that they shall have lower rates of insurance or be able to do without insurance.

The Manufacture of Concrete Blocks and Their Use in Building Construction.

Extracts from Papers Submitted in ENGINEERING
NEWS Competition.

Besides the two papers given, which were awarded prizes in The Engineering News competition, there were received several others, nearly all of which contained contributions of value to the knowledge of the subject of concrete block manufacture and use. From these papers selections have been made and arranged under descriptive headings.

The names of the writers from whose papers extracts have been taken are as follows

Joseph Babiczky, Kansas City, Mo.

George H. Crafts, Atlanta, Ga.

H. H. Frantz, Des Moines, Ia.

U. G. Hayne, Fort Stevens, Ore.

Noyes F. Palmer, Brooklyn.

H. H. Rice, Denver, Colo.

H. G. Richey, Evanston, Wyo.

G. W. Robertson, Marion, O.

G. W. Stevens, Boston, Mass.

LOCATION OF PLANT.

U. G. Hayne.—The points to be considered in establishing a concrete block plant, or factory, are many and various, every locality presenting different difficulties and problems to be settled. The one vital question to be thoroughly looked into and decided before installing a plant in a locality, is: "Will it pay?" In connection with this query must be considered the climatic conditions, and the kind, price and quality of the building materials provided at hand by nature. The facility and cheapness with which good materials can be obtained for making blocks in the locality under consideration should also be closely investigated. It may be that the custom of using a certain building material in a community is so set that in order to get a trade established it will cost considerable

in advertising, rustling and time before good results can be obtained. With enough capital this question is easily settled, but it may mean failure to a man of small means before he can get returns.

In years past some one may have so handled concrete work in a locality that a prejudice exists against its use; he having used a poor quality of sand, gravel, or possibly cement; though an even chance poor workmanship. It little matters what the error has been; results will be slower and more expensive until this sentiment is overcome. Therefore the place not so hampered, for the man of small capital, is the best; though a hustler with good goods to make good with, can win out in any community.

A locality that has supported a brick-yard of any size should be able to furnish work for a block plant, though there are many such places where the cost of transporting the sand, gravel and cement will practically prohibit manufacturing blocks at a profit. While, on the other hand, all the materials for block-making may be close at hand, and cheap, in a locality that has no materials for brick-making.

Stone in some places may be cheap enough to materially interfere with the use of concrete blocks on account of cost. I think that such cases are rare. No doubt but that brick cuts a more important figure, though I know of instances where the price of brick, a few years ago, could not be touched with concrete for foundations even, including basement walls; where now more than half the work is concrete, and growing in favor. Timber in some localities has to an extent kept out concrete, and will for some years to come; but owing to a material advance in the price of lumber, conditions are changing.

Having decided on the community or town in which to locate, the next item to be considered is the location of the plant. This should be as nearly as possible so situated that the cost of transportation will be reduced to a minimum. The cartage on the finished block will be, in most instances, more for the same distances than that of the raw materials. So a location central for the finished product should be looked for, at the same time keeping in mind that, if possible, a location near a railroad siding will be very convenient. On account of receiving cement, and, in many instances, sand and gravel, by rail, the expense account can be kept down, as well as being in a position to make shipments of the finished product, with all cartage cut out. Where water transportation is possible, it should be considered in this connection.

The plant should be located where water under pressure can be cheaply obtained, either from the city mains or a system constructed for the purpose, as water under pressure must be had for sprinkling the blocks and the various uses of the factory.

In many instances an old mill building or warehouse with sufficient ground adjoining for a yard can be utilized much cheaper than constructing a building.

H. G. Richey.—As the location of the plant will be one of the first considerations in starting a concrete block business, the points to be given the most attention are, the market for the finished product and the proximity of the raw materials; and then after the plant is in operation to turn out a finished product equal or a little better than any other like material on the market. Rather make a high-priced good block than a low-priced poor one; for no person will wish to buy a poor block at any price, but generally people will pay a good price if they know they are getting a good block and their money's worth.

A concrete block plant should be so located that the bulk of the materials to be used can be obtained with the least expense possible. As the broken stone or gravel forms the larger quantity of material to be used, the plant should be, if possible, located adjacent to this supply; if this point is on a railroad, it will also save the expense of hauling the cement from the car to the plant. Another advantage of being located on a railroad is, that the finished blocks can then be shipped by rail to other points, and there will be no expense of hauling from the plant to the car.

DESIGN AND ARRANGEMENT OF PLANT.

U. G. Hayne.—In parts of the country where the winters are cold, a basement, in which to work the men making blocks for the spring trade and to keep the crew together, would be a good investment. Should the location selected have a plot of ground that can be secured and converted into a factory, such as will answer the purpose of the block manufacturer, he can use his best judgment in arranging it to suit his requirements.

In case he has to build and his capital is limited, a cheap wood building large enough to hold about four days' work, with a floor of fine sand, and windows so placed as to give a good light about the part of the building where the making of the blocks is done, will be sufficient in size to start with.

As the blocks must be kept from the sun and wind as much as possible for about ten days, the yard can be so arranged as to keep off the wind by fencing, and on sunny days canvas can be spread over the blocks in the yard which have not been stacked out over six days, or, in other words, over those blocks that are being kept wet. For an output of about 1,000 blocks per week a room will be required approximately 30 ft. wide by about 80 ft. long for the machine, mixing-platform, and room for curing the blocks. By stacking and re-handling the blocks once, this room is large enough to double the capacity.

A close-built mixing platform about 12 ft. x 14 ft. should be placed alongside the block machine, which must be in such a position as to make it handy to the materials, preferably close to one side of the building. The sand or gravel can then be shoveled directly onto the platform from the outside. Where a mixer is to be used, the plant can be so arranged that the materials may be placed in the mixer by machinery, or by gravity, thus doing away with practically all shoveling.

When it comes to a factory the size of which it will pay to so arrange that all mixing, tamping, etc., is done by machinery, the party interested in installing it should take sufficient time and money to investigate the subject thoroughly, and know just what he is doing. My object in this article is to give any information I can that may be of use to the man who has to start in a small way at making blocks or not be able to start at all.

In large plants an arrangement of tracks and cars will be very necessary in handling the blocks about the building and yard. Most machine companies have cars and tracks for handling and curing the blocks, and can give the best arrangement of them for handling the output of their respective machines.

The factory should be so piped that the new-made blocks can be easily and cheaply wet down with a spray of water from one or more sprinklers.

The arrangement of the yard, to facilitate the loading of the finished work, for transportation to the place where they are to be used, with roads through it at convenient intervals for driving trucks, should not be forgotten.

In most cases it will be best to make the blocks at the factory, and haul them to the place where they are to be used in the building. Yet where a large number are under consideration, at a distance from the factory, it may be profitable to make them on the site of the building to be constructed. A contract or two of this kind would save enough to purchase a tent of sufficient size for the purpose that could be used to good advantage on similar work.

Included in the plant are the shovels, hoes, etc., for mixing; the hose and piping for wetting down the blocks, etc.

Some of the various companies selling machines make a metal bottom board or pallet for making and curing the block on, and which has the advantage of not being liable to check or crack the stone as a wood pallet is apt to do, on account of the wood swelling by absorbing the moisture from the block. Should the wood pallet be kept wet and watched on account of the shrinkage from drying out, they are all right, and much cheaper.

A factory such as spoken of, with the building only high enough

to work in, and ready for the machine should cost from two hundred to five hundred dollars.

G. W. Robertson.—One wishing to engage in the making of blocks, etc., should first select a suitable location after having ascertained probable cost of cement, sand, crushed stone, etc., and finding out probable price he can get for blocks. A location should be selected as handy as possible for the handling of material of all kinds, also for shipment of product, and not too cramped for storage room, as in the handling, re-handling, piling, etc., money is either made or lost. In this business, as in any other, it is the seconds that count. Therefore, it stands you in hand to have everything convenient. The shed or shop for making block, mixing concrete, etc., can be light and airy, while the part of shed where blocks are placed after making should be rather dark, or at least protected from sun and wind till they are fit to move into the yard, this in spite of the claim made by some that blocks can be made either out in the sun, or any old place that may be handy, and given no protection. In arranging the shed or shop, care should be given to have the place for cement as dry as possible.

Joseph Babiczky.—In a large city where a well-organized concrete block company is working successfully, it is perhaps advisable to build a regular factory equipped with the most perfect machinery for turning out high-class and speedy work. Start in always, however, with a tent plant, and when you see that you are successful in the business, consider a permanent plant. In the following table I give the price and size of tents for various daily outputs of concrete blocks:

Dimensions, ft.	Area.	Daily capacity, No. blocks.	Cost of tent.
40×61	2,076 sq. ft.	300	\$150
44×65	2,444 "	400	175
44×72	2,752 "	500	190
48×76	3,152 "	700	215
52½×80½	3,633 "	950	350

After it is seen that it is absolutely necessary to put up a permanent factory, equipped with power mixer, power presses and molds of various sizes and kinds, the tent outfit, with the hand machines, can be used as a "flying factory," which can be packed up in a few hours and shipped to any place outside the city where work may be contracted for. I think that the shipping of concrete blocks is very seldom profitable, on account of high transportation rates, cost of handling and packing, and loss from breakage.

Geo. H. Crafts.—In order to make blocks in the cheapest way, judgment should be used as to the proper location of the plant for business, and the location and design of the buildings and placing of the machinery therein so as to bring the operating expenses down to a minimum. If possible, it is best to locate the plant near a good sand bed, as sand is one of the principal materials used.

Then the buildings should be located so that the sand can be gotten into the bins with the least expense, and the bins should be of ample capacity to keep a surplus of dry sand on hand at all times. The boiler and engine, pump, press and mixer, should be so placed that the material can be put through the different processes of proportioning, mixing, pressing and curing with as little handling as possible, and so that the processes can be carried on continuously and with as little interference of one operation with another as is possible. The mixer should be placed so that the materials can be measured and charged into it from the sand bins, and discharged from it in close proximity to the loading platform. The platform should be in line with the press, and the transporting apparatus such that the material can be put through the press and be deposited in the curing shed in the safest and quickest manner. An overhead traveler costs little more than ground tracks, and leaves more ground room for the placing of the blocks. The curing shed should be large enough to hold a week's product of blocks, and should have a sprinkling apparatus throughout the length and breadth of it, so that all the blocks can be kept wet at all times. It is advisable to have the sides of the building closed in so as to keep the sun from shining on the blocks and the wind from blowing the spray about too promiscuously.

In order to conduct a plant successfully, it should be fitted up to make not only building blocks, but also window and door sills and lintels, caps and copings, columns, balusters, rails, posts, and all other building forms; also walk tiles and street curbing, etc. All three of the processes of putting into mold can be economically used; the pouring for complicated patterns, as capitals, columns, balusters, etc.; the tamping process for all blocks where only a few in number of a size are required, and the pressure system for the majority of the work where a number of blocks of the same size and pattern are needed.

The accompanying photographs (Figs. 1 to 6 incl.) are of a large and successful Artificial Stone Plant. This is located near a thriving city at the junction of two railroads and on a navigable stream. There is an inexhaustible bed of the finest building sand on the property, and immediately adjacent to the buildings. The buildings consist of a two-story frame building, about 20 ft. by 30 ft., with pattern shop above and mixing and pressing room below; connected to this building is a one-story building containing boiler, engine and pump. Adjoining the press room is the curing shed, which is an enclosed frame building, 150 ft. long by 45 ft. wide. The machinery consists of a 15-HP. boiler, 12-HP. engine, Fisher hydraulic press, cubical mixer, Hexagon tile smoother and ventilating fans. There are two lines of overhead tracks in the curing shed, and

MANUFACTURE AND USE

ground tracks from the mixer through press and to the switch tracks through the yard. There is an artesian well flowing at 150 gals. per minute within 100 ft. of the curing shed, and pi

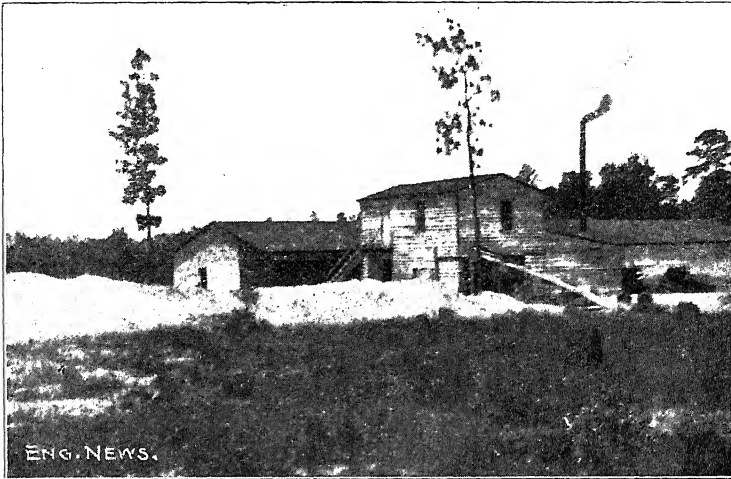


FIG. 1. General View of Concrete Block Plant.

throughout the building with sprinkling devices. This plant is equipped for manufacturing in the most approved manner any concrete that can be made out of concrete, with or without reinforcement, and it is managed by men with a thorough knowledge of con

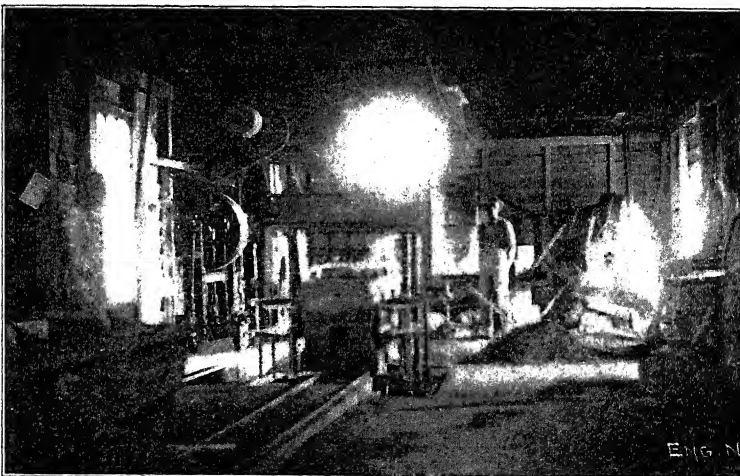


FIG. 2. Interior View of Press and Mixer Room.

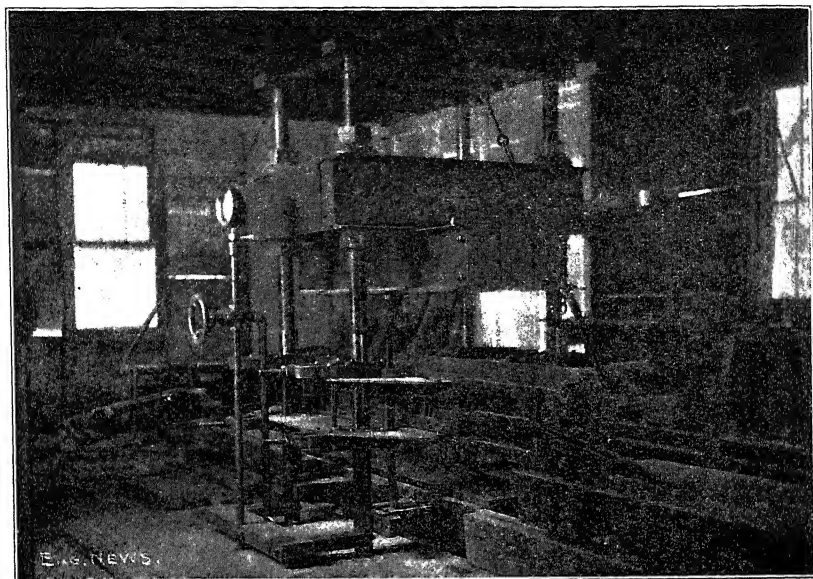


FIG. 3. View of Hydraulic Press.

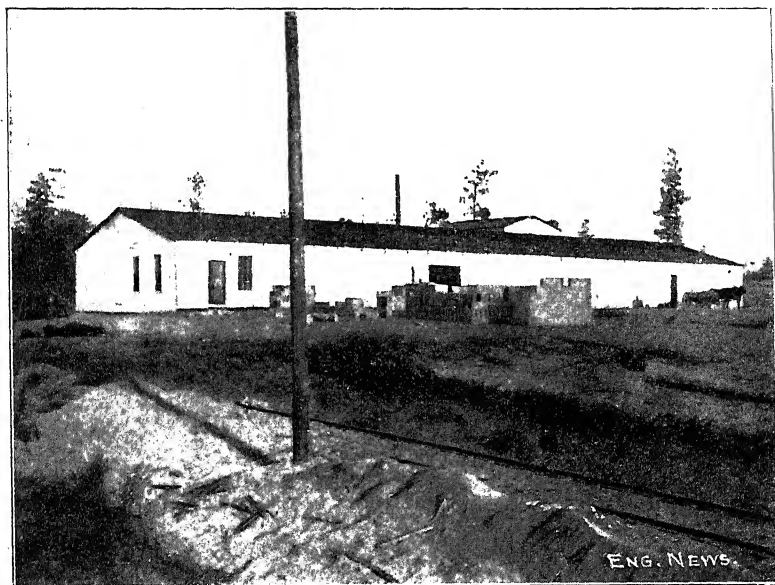


FIG. 4. Exterior View of Curing Shed and Yard.

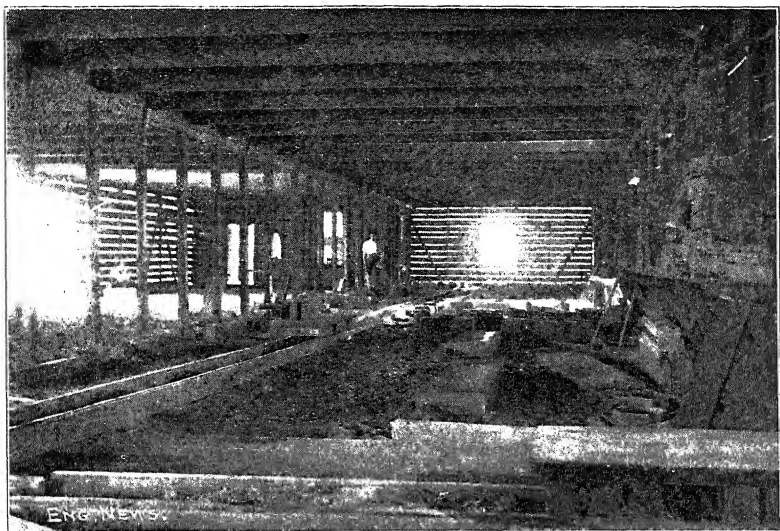


FIG. 5. Interior View of Curing Shed, Showing Slatted Walls.

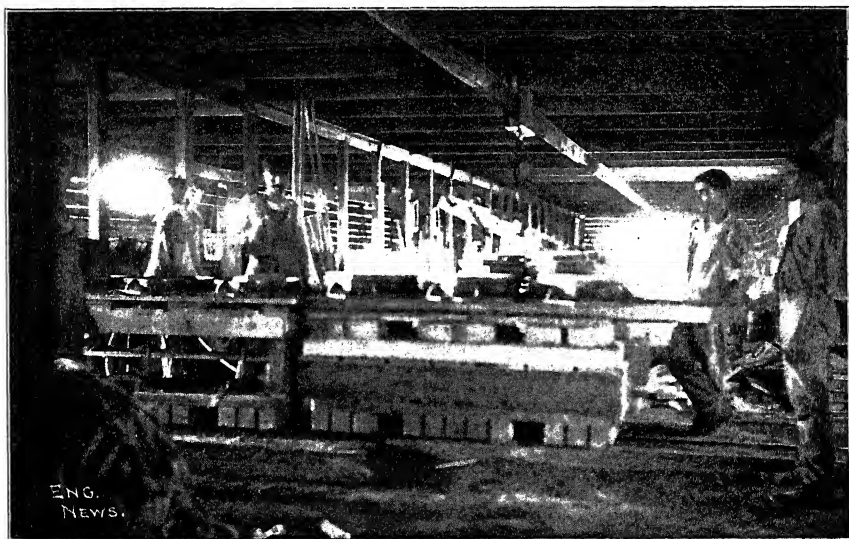


FIG. 6. Interior View of Curing Shed, Showing Overhead Trolley Tracks and Molds.

and its uses, and who keep abreast with the advance knowledge on the subject.

FORMS OF BLOCKS.

H. H. Rice.—To one contemplating the manufacture of concrete blocks as a business there is nothing more important than an exhaustive consideration and investigation of the various shapes, sizes and designs in which blocks have been constructed. Such investigations should not stop with the forms now in actual use, but should extend to all possible forms and their combination in finished buildings. Let us begin with the crudest idea in block construction—a solid concrete block. We note that it has all the advantages of natural stone, that it may be molded in any size or form desired, that it is ready for its place in the wall without chisel or hammer, and hence all expense of cutting and dressing is eliminated, that each block fits in its intended place with a consequent saving in time and annoyance in laying, that the blocks are made on the ground where needed, thus making an enormous saving in cost of transportation, that the walls tend to grow in strength for many years while stone tends toward disintegration from the day it is exposed to atmospheric influence, and, lastly, that it sustains an enormous crushing strain.

The next step in block construction is taken in fulfillment of a desire for a hollow wall, and is exemplified in the use of slabs tied by metal strips and leaving an intervening air space, the effect produced being equivalent to two walls with air space between. Though crude in a way, it is scarcely necessary to elaborate on the advantages of such construction. The building is warmer in winter and the saving in consumption of fuel is estimated at 25%. It is more comfortable in summer. It is sanitary and free from vermin. While moisture may penetrate the outer shell, it cannot pass the air space, and hence the interior is dry in all weather and in all climes. Thus furring and lathing are unnecessary, and plaster or other decoration is applied directly to the interior walls. The patent disadvantages of such construction rest in the metal ties, which are subject, on account of moisture penetrating the outer shell, to rust and corrosion, and experience indicates that they readily attract lightning. However, such a house may be seen in the State of Kansas, now well preserved, though built over twenty years ago by its present occupant; the Fine Arts Building of the Lewis and Clark Exposition is of this style of construction.

To provide a wall having the advantages of the air space without the disadvantages mentioned as appertaining to the metal ties, and to secure throughout the wall a uniform, durable and fireproof material, the hollow block was brought forth. Some 17 years has this block now been in use in America, and it may be described

as having an outer and an inner face united by transverse sections or webs, and containing intervening air spaces. When laid in the wall these blocks break joints between alternate courses. The hollow spaces form continuous perpendicular flues. By far the greater number of concrete block buildings in the United States are of this type, and it is not difficult to find factories in operation under some one of the many systems producing this style of block. But man is ever alert for improvement, and experience showed a defect in this construction in that moisture would follow the transverse sections or webs through the wall, causing dampness on the interior and necessitating furring and lathing.

With the view of obviating this fault blocks were devised in which no transverse section passed directly from the outer face to the inner one, and while retaining the external form of the blocks alst mentioned the interior construction is such that the cross webs are broken by perpendicular or longitudinal sections, the webs in this type of block assuming a staggered, zigzag or S shape. This considerably impedes the passage of moisture and makes it possible to preserve a dry wall to a much greater degree than in the form of block last described.

In the evolution of concrete block construction there next follows the development of various forms of angle blocks, being modifications of the "T," "U," "E" or "L" shape, which will, by reason of certain characteristics common to all, be considered in this discussion of structural form as a common type. Of these characteristics we may especially note: (1) That no single block or portion thereof extends through the wall; (2) that no single block possesses both an outer and an inner face; (3) that the blocks in laying a single course overlap breaking joints laterally so that in any given course no joint passes through the wall, while the alternate courses break joints perpendicularly, as in types already considered; (4) that the arms or webs of alternate courses overlap from side to side in such a manner as to form an alternating cross bond extending from the inside of the outer face section to the outside of the inner face section; that is to say, the bond extends almost through the wall; (5) each block is held in place by eight other blocks to each of which it is joined by cement mortar; (6) by leaving the interior joints open a quarter of an inch a continuous horizontal air space exists throughout the wall, and we have in effect two walls tied by the overlapping of arms or webs in alternate courses; (7) by a clever interlocking bond a wall may be produced of any desired width, containing not one, but three, five, seven or more air spaces.

As the development of this type is comparatively new, a brief discussion of these seven points may be profitable. The first precludes the passage of moisture by capillary attraction. The second

affords greater facility in facing. The third makes a frost-proof wall. The fourth affords the greatest lateral strength of any known masonry construction. The fifth makes a wall almost monolithic. The sixth gives an insulated wall practically fireproof, a non-conductor of heat, a wall dead as to sound and impervious to moisture. The seventh affords a desirable wall for ice houses, refrigerating plants and packing houses, as well as for bridge abutments, piers and retaining walls.

Thus far we have discussed the various forms of blocks for ordinary or main wall construction, but these alone would not build a house. We must have numerous special blocks. As all systems break joints perpendicularly, half blocks must be used in alternate courses to finish at the end of a wall. Corner blocks must be produced with a return of such length as will conform to the general plan and preserve the bond in the wall. Openings for windows and doors must be provided with jamb blocks of different designs according to the character of casings to be used. The above indicate only a few of the absolutely essential forms of blocks which every system must provide before it can make any reasonable claim to patronage. In addition I may mention lintels, sills, caps, coping, belt courses, arch blocks, keystones as essential architectural members fairly coming under our title.

Joseph Babiczky.—The size of blocks is limited by their weight. A block weighing more than 100 lbs. cannot be handled with ease and speed by one man; it is better not to exceed 75 or 80 lbs.

Geo. H. Crafts.—The one-piece block is simpler to lay in the wall and has been the block principally used up to within the last year or so. The two-piece is a lighter block to handle to make the same size face stone, can be made of mere compact material and gives a stronger bond in the wall.

SELECTION OF MATERIALS.

The standard ingredients for concrete blocks are Portland cement, natural sand and crushed stone or gravel. Hints on the selection of these materials are found in the following quotations:

CEMENT.

H. H. Robertson.—Manufacturers should make some simple test to determine what brands of cement give the best results as to color when combined with the sand and aggregate it is expected to use. Prefer cement to be shipped in paper bags, as no care has to be expended in preserving bag, there is less loss by cement sifting out, and paper is less easily penetrated by moisture than cloth.

H. H. Rice.—Having selected a certain brand of cement, stick to it; different brands differ in color; furthermore, there is a difference in the way cement works; one's mixture may be ideal with a certain brand, and give much trouble with another brand.

H. G. Richey.—Puzzulan cement should never be used for making concrete blocks, as such blocks fail from cracking and shrinking (at the surface only) in dry air; in damp places this cement is equal to and in some cases better than the best Portland cement. Color is one of the points to be considered in selecting a cement for making concrete blocks, as the various brands dry out in different colors, some being dark and some light in shade. It would be well to keep samples of blocks made from the different cements to show customers the various shades to be obtained.

Geo. H. Crafts.—Various substances having claims to strengthen or accelerate the action of Portland cement are on the market, but they should be used with great caution, as even if they do appear to strengthen the material when first made they may have a deteriorating action.

SAND.

Since nearly all the writers specify clean and sharp sand, this quality will be understood in the following quotations unless exception is recorded.

U. G. Hayne.—Test sand as to fire-resisting quality, when blocks are liable to be subjected to fire.

Geo. H. Crafts.—A small proportion of clay makes blocks of a damp mixture stand up better when made, and does not appear to decrease their strength; but too much clay is undoubtedly injurious.

Noyes F. Palmer.—Sand that will not absorb water should be avoided. We had a ton of special sand sent to us; it was the kind used in the manufacture of glass, and sold at \$10 per ton. We had difficulty in handling green product made with it, and when the product was cured it looked like "shad roe" when examined with a magnifying glass; the sand grains were all piled on top of each other with voids between. To the naked eye the face looked white and smooth, but the tenacity of the face was lacking.

G. W. Stevens.—Divide sand and gravel into two classes each, viz., fine and coarse. Sand that will go through a sieve having 24 meshes to the inch, call fine sand; of the remainder that portion which will pass a sieve of six meshes to the inch, call coarse sand; of the remainder, that portion which passes a sieve having two meshes to the inch, call fine gravel, and of the remainder, that passing a 1-in. mesh sieve, call coarse gravel. This classification is followed in the proportioning of the mixture. Both sand and gravel should be entirely free from soft stone, or any other material that will absorb water, because such particles when near the surface are liable to freeze and burst out.

H. H. Rice.—Rolling sand between the fingers is an excellent method of determining what is a proper material. In this manner

one can determine the relative strength of sand particles, detect the presence or absence of clay, loam or other foreign substance, and observe the presence of "grit." A gritty sand is essential, but loam or clay in any considerable quantity becomes fatal, and necessitates washing. Test the sand not only dry, but ascertain also what effect water will have on it. If wetting causes it to loose somewhat of its "grit" and sharpness, and it shows a tendency to dissolve, or reminds you of the action of sugar, discard it.

H. G. Richey.—Sand for the face should be fine, and that for the body of the block should be coarse, or, better, should range from fine to coarse. The sand for the face, if not perfectly clean, should be washed; that for the body may contain about 5% of clay without detriment to the strength of the block. There must be no clay in the sand used for the face or exposed part of the block.

Joseph Babiczky.—Experiments show that sand containing up to 10% of finely distributed loam makes just as strong and durable concrete as does clean sand. It is to be noted that the loam must be uniformly distributed, and not be in lumps; furthermore, sand containing more than 2% of loam, even finely distributed, must not be used in winter work as freezing destroys the cohesion. Sand must be free from any kind of organic substance such as roots, leaves and straw.

SUBSTITUTES FOR SAND.

Joseph Babiczky.—The following materials can be used in place of sand in making concrete blocks: (1) Fine crushed stone, which can be obtained at no extra expense if the rock is crushed to maximum $\frac{1}{4}$ -in. size, when so much dust will result that the voids in the clean crushed stone are completely filled. This is an ideal material for concrete. (2) In the Southern states, where no sand is obtainable, crushed oyster shells furnish a very good, clean and sharp material, whose only objection is that blocks made from it do not resist fire very well.

GRAVEL AND CRUSHED STONE.

H. G. Richey.—The aggregate may be either broken stone or gravel, whichever is the more convenient and the cheaper; it should be of a size to pass a 1-in. mesh sieve. Some manufacturers of concrete blocks are using sand and gravel combined, as it comes from the pit or river bed; this is poor policy, for the sand and gravel are not uniformly mixed nor in correct proportions; some blocks will have too much sand, and some not enough. When the sand and gravel are found together, they should be first separated by screening, and re-mixed in correct proportions; in this way only can a uniform mixture be obtained.

Joseph Babiczky.—Crushed stone should consist of particles varying in size from pieces passing a $\frac{1}{2}$ -in. ring to fine dust. Limestone in no form is permissible, because when the block is heated the

limestone is calcined to quicklime, and the blocks collapse, particularly if water is thrown on them.

H. H. Rice.—The choice as between gravel and broken stone must often depend upon the local availability of the two; where both are obtainable with equal facility there is some difference of opinion as to which is preferable. Personally, I favor gravel, as ordinarily possessing greater strength and firmness, although numerous operators are using stone with marked success. Both materials should range in size from "pea" up to as large as can be accommodated in the particular style of mold or machine in use. Remember always that the object is to manufacture stone, and the more of the large sizes contained in the aggregate the more do you take advantage of the help which nature offers in the stone already produced, and the more easy has your art become. Remember again, that you can only make real stone by coating every particle of the aggregate with cement; the smaller the particles of the aggregate the greater is their resulting number, and the greater the amount of cement required to secure the requisite crushing or tensile strength. Hence with a given proportion of cement, the strength is increased by increased size of the aggregate members. This theory has been well substantiated by exhaustive laboratory tests and by practical experience in general concrete work.

Noyes F. Palmer.—It is generally accepted that trap or granite broken into pieces not larger than hen's eggs make the strongest block; that the more stone dust used the fewer voids; that broken stone that averages the size of chestnuts, with fine stone dust included, is easy to handle and manipulate in block manufacture, and makes a neat finish, while too large stone aggregates necessitate slower work.

U. G. Hayne.—For block work no gravel that will not pass a $1\frac{1}{2}$ -in. screen, placed at an angle of about 30° with the horizon, should be used. Great care should be taken to have the gravel clean; even though it is worn quite smooth it is all right providing it has the necessary tensile strength and toughness. Broken stone of good texture that will break cubical in form, with the crusher dust left in, will make good blocks.

SUBSTITUTES FOR GRAVEL AND STONE.

Several writers mention the possible substitution of crushed slag, crushed brick, crushed tile and cinders for the usual gravel or broken stone aggregate, but only one gives specific information.

Joseph Babiczky.—Old bricks of hard quality furnish a cheap aggregate for concrete blocks when crushed. Cinders offer many advantages as an aggregate for concrete, but must be used cautiously as they often contain dangerous impurities and particles of unburned coal. They must be carefully washed, screened of ashes,

and the coarse particles crushed. Cinder concrete blocks must always have a sand mortar facing about $\frac{1}{2}$ in. thick. It should be noted also that cinder aggregate gives a block weighing about 40% less than blocks of the usual cement, sand, stone mixture.

MIXING WATER.

Few of the papers make any statement as to the quality of the mixing water to be used in making concrete blocks.

H. H. Rice.—Use clean water. Don't spoil your blocks with dirty, impure, muddy water. After performing the physical operation of block-making we feel that we have made stone, while we haven't done anything of the sort; the chemical action of the water upon the cement, causing crystallization of the silicates, is the real process of stone-making. We want the most perfect chemical action obtainable; therefore, use the best water obtainable.

PROPORTIONING OF MIXTURE.

The proper proportioning of the various ingredients is a question upon which the several writers exhibit great divergence of opinion.

Joseph Babiczky.—My experience is that 1 part cement and 5 parts sand properly mixed, tamped, handled and cured gives blocks as good as any common building stone. If suitable crushed stone can be obtained, a combination of 1 part cement, $3\frac{1}{2}$ parts sand and 6 parts stone makes a good mixture supposing that the sand is not too coarse and the stone varies in size from $\frac{1}{2}$ in. to dust.

G. W. Stevens.—For the wet process the following proportions can be used: 1 part cement, 1 part fine sand, 2 parts coarse sand, 2 parts fine gravel and 2 parts coarse gravel. For the dry process the following mixtures are suitable: (1) For facing, 1 part fine sand, 1 part coarse sand and 1 part cement; for backing, 1 part fine sand, 2 parts coarse sand, 3 parts fine gravel and 1 part cement. (2) For one mixture throughout, $\frac{1}{2}$ part fine sand, $3\frac{1}{2}$ parts coarse sand and 1 part cement. (3) Same face mixture as above; for backing, $\frac{1}{2}$ part fine sand, $2\frac{1}{2}$ parts coarse sand, 2 parts fine gravel and 1 part cement. (4) 1 part fine sand, 2 parts coarse sand, 3 parts coarse gravel and 1 part cement.

Noyes F. Palmer.—In regard to cement and its aggregates, it matters not if it be a mortar block of 1 cement and 4 sand, or a concrete block of 1-2-4 or 1-3-5 composition. The practical thing is to find out how to fill the voids in all cases so as to get the greatest strength in the cured block.

U. G. Hayne.—In most cases a mixture of 1 part cement to 4 parts sand should be used for blocks. This proportion can be used where blocks are to be put to the severest test as to fire, compression, tension, etc. I would recommend a facing of about $\frac{3}{4}$ in. in thickness of 1 part cement and 2 parts sand mixed a trifle drier than

the body of the block. This will permit the face mold to part freely from the mortar leaving a clean cut face.

H. H. Frantz.—Use mixture of 1 cement, $2\frac{1}{2}$ sand and $3\frac{1}{2}$ broken stone proportioned by measure.

G. W. Robertson.—To determine practically the amount of cement needed for making a good block have found a simple and satisfactory way to be to get two graduates such as druggists or photographers use, one of say 24 oz. and the other of 8 oz.; fill the larger with the coarse aggregate and then from the smaller pour in water until it stands on top of the material; note amount of water used; empty large graduate and fill with same material, to which add the amount of fine material (sand or stone dust) indicated by the amount of water noted; mix the fine and coarse material thoroughly, then add water from smaller graduate as before; the amount of water used will give amount of cement needed to make good blocks.

CONSISTENCY OF MIXTURE.

In respect to consistency, practice classifies concrete mixtures for block manufacture into wet mixtures and dry mixtures. Concrete block machines are designed specifically to use one or the other of these mixtures.

H. G. Richey.—It is the opinion of the writer that the use of such a number of molds as will permit the mixture to be left in the mold about 12 hours will result in the production of the better blocks. The concrete can then be mixed with enough water to permit solid tamping and to provide for the proper crystallization of the cement; this will make a much harder and more dense block than many of the dry mixtures now in use. In making a block where the mold has to be removed immediately the concrete must be dry enough to stand up when the mold is taken away, and the block must stand from 6 to 8 hours before it is safe to wet or sprinkle it without fear of destroying the face or arrises. Concrete made as dry as this and then exposed to the air while the setting of the cement is taking place has not sufficient water to cause complete and correct crystallization. The writer does not advocate a mixture so wet that it can be poured into the molds, but the mortar portion of the concrete should be of about the same consistency as mortar used for laying brick or stone.

Geo. H. Crafts.—About 10% by weight of water is the proper proportion to use for the mortar for tamping and pressure processes, but about double this amount is necessary for the pouring process.

U. G. Hayne.—While the reason in favor of employing the make of machine that uses wet flowing concrete and permits it to set in the mold is a good one, it is more than balanced by the large number of molds required for work. Where reinforcing prevents thor-

ough tamping, or where the surplus water can be quickly drawn off, are the only cases in which I would sanction an excess of water in this class of construction. When well tamped in the mold there should be just enough water in the concrete to show on the iron tamper.

H. H. Frantz.—The mixture must be made sufficiently liquid that the mere shaking of the mold will settle the mass; a stone thus made will be found far better and much more impervious to water than one made by the dry process.

Joseph Babiczky.—For tamping and pressing the materials must be mixed with only so much water that the mixture is of the consistency of damp garden earth. For the pouring process the mixture must be so wet that it runs easily out of the buckets.

G. W. Stevens.—I am in favor of wet concrete. The concrete should be made wet enough to flow freely under the cores and into the corners.

Noyes F. Palmer.—The less water used in the process of molding mortar or cement blocks the less voids and a resultant greater strength.

METHODS OF MIXING.

Two methods of mixing the ingredients, first machine mixing and second hand mixing, are available in concrete block manufacture as in general concrete work.

G. W. Stevens.—A wooden floor should not be used; a cement or earth floor with a coating of fine sand spread over it is a desirable one. In summer, especially, have the mixing floor so that the sun does not shine on it, and where there is no draft of air.

Joseph Babiczky.—The ingredients must first be thoroughly mixed dry and then wet; if mechanical mixing is employed the mixer should provide for separate dry and wet mixing; it should also provide for the addition of the water in a fine spray.

H. H. Frantz.—Provide yourself with a mixing box on wheels; box should be say 6 ins. deep, 5 ft. wide and 5 ft. long. Place in the box $2\frac{1}{2}$ parts by measure of sand well scattered, spread over this 1 part of cement and mix thoroughly with hoe, shovel or rake. Next add clean water and beat up to consistency of soft mushy mortar. Finally add $3\frac{1}{2}$ parts of gravel and mix and beat to a soft mixture.

H. G. Richey.—When the plant is large enough to justify the expense a power mixer will be the most economical as well as the most convenient. For a block plant a batch mirror will prove the best, for by it the concrete can be mixed as thoroughly as desired. In any machine mixing the cement, sand and aggregate should first be mixed thoroughly while dry, then the water should be added in just sufficient quantity to make a soft plastic mixture, which

will tamp readily in the molds, and after being tamped lightly will quiver at each stroke of the tamper. When the mixing is done by hand with shovels or hoes, the cement and sand should be mixed dry, then with water to make a mortar of the consistency described. Finally the aggregate previously wetted should be added and thoroughly and evenly incorporated with the mortar.

Geo. H. Crafts.—Undoubtedly machine mixing is much better than mixing by hand as it is much more thorough. A batch mixer mixes thoroughly all the ingredients of a batch, and can be kept running continuously if the material is not wanted just at the time it was mixed, whereas a continuous mixer has to be stopped, since it will not continue to mix the same material. It is better to mix the materials in a dry state at first and then gradually add the water in a spray and continue the mixing. The longer the mixing is kept up the better, as experiments show that the strength of concrete is increased by mixing even up to two hours after being wetted.

U. G. Hayne.—Hand mixed concrete should be mixed on a tight platform, or in a large mortar box, with square pointed shovels or mortar hoes. Measure and spread the sand evenly over one side of the platform, or in one end of the mortar box, care being taken to have it spread evenly and 8 ins. to 1 ft. in thickness. On top of this spread the required quantity of cement, taking care to have the cement well distributed on the edges of the layer of sand. On each side of the platform place a man with a square pointed shovel prepared to shovel the concrete to the vacant side of the platform. The shovel should be run along the edge of the pile, filling from what rolls down and when full should be turned to a separate pile with a spreading motion, care being taken to have all the pile thoroughly turned as there is a tendency to first to slight the portion where the two shovels meet. The object of the shovelers should be to have gravity aid in the mixing as much as possible by handling the concrete so that it rolls down on the pile, being shoveled from as well as on the one shoveled to.

Two or three good turnings should give the concrete an even color, if not, it should be turned until it is of one. Then the concrete should be evenly spread out and the water added, preferably with a sprinkler, though I have seen no evil effects from taking the quantity of water required and gently pouring it on top of the pile, and after letting it stand for two or three minutes mixing in the same manner with the shovels as before, adding the water. The turning should be continued until the water is thoroughly incorporated in the concrete, and, when finished ready for the molds, a quantity of the concrete tightly squeezed in the palm of the hand and the hand opened palm up, should remain like a ball on the hand.

Using the mortar box and the hoes, the sand and cement should be spread in one end of the box evenly, the same as described for the platform. The man mixing then stations himself at the opposite end, and hoes the concrete toward him with a quick downward stroke, pulling quickly toward him at the same time the stroke ends, and taking a cut of about an inch into the concrete each time. This quickly and thoroughly mixes the concrete. Turn the whole quantity back the same way to the end it was first in, or two turnings, add the water and turn until the mixture is all of the same wetness.

There is no question but that machine mixed concrete, where the machine is correctly used, is better and more thoroughly and cheaply mixed, than by hand, and as soon as the business will justify it one should be used. Would not attempt to use a hand-power mixer but a gravity or power one. The danger to be avoided above all, though is to not mix too much concrete at once, as the temptation is too great to use it, if mixed, even though the initial set has begun. With some cements, concrete used within $1\frac{1}{2}$ hours is all right, but with most 20 to 30 minutes is about the limit.

BLOCK MACHINES AND MOLDING.

Concrete block machines are designed to use either a wet, a machine or a dry mixture, and the construction of the machine and the process of molding vary for each mixture.

H. H. Rice.—The most simple form of mold ever devised for making a hollow concrete block consists of two side boards with cleats to engage end boards, clamps to keep the sides in position, two or three pieces of stove pipe to form the hollow spaces, with a piece of 2 x 4-in. timber for a tamper, the latter shaved at one end to fit the hand. If you have some knowledge of cement and a little mechanical skill, it is possible for you to make very good blocks with this outfit. If you do not understand the action of cement, and have no mechanical skill, it is possible for you to make very poor blocks with the latest improved appliances. And I may here say that the genius of the inventor and the mechanic is exemplified in varying degrees from the mold I have described to the most modern machinery in block manufacture, while the energy, perseverance and ability of the operator are displayed in varying degrees from blocks whose quality has irreparably injured the standing and reputation of artificial stone to beautiful, lasting and symmetrical edifices, which are things of beauty and a joy forever. Don't forget that the best machine requires mechanical commonsense to obtain the best results.

I have said that all processes are roughly classified as tamped, poured or pressed, and again, in the same order, as dry, wet or medium. I shall first consider the machines for making blocks by the comparatively dry hand tamped process. These machines con-

sist, in general, of a stand to bring the bed to convenient working height surmounted by a mold containing interior cores. The mold is filled with a moist mixture of sand and cement, tamped well as the mold is filling and slightly heaped up at the last to permit leveling off with a straight edge. Now there are very many different machines of this type in market to-day, and their chief differences may be summarized as follows: Some drop the interior cores mechanically from the block, then unclamp and drop the sides, thus leaving the block free on the bottom plate ready to be carried to the curing yard. In others, the cores and the frame surrounding the mold are stationary while the bed moves upward to release the block and the same upward motion disengages the sides from the surrounding frame, allowing them to fall away from the block; when the bed is lowered the cores come into proper position and the outer frame engages the hinged sides and ends so that one downward motion throws the entire mold into position for re-filling. In others the sides are hinged on a corner, the bed stationary and the cores movable, so that in releasing one side and one end are laterally withdrawn from the block and the cores dropped out of the block, as in the kind first described. Still others have longitudinal cores which are withdrawn by hand. Certain of these machines have a device for throwing the mold at 45° angle to permit of applying face matter as already mentioned. Another type of machine, though following the same general lines of construction, has the mold turned on the side to more easily face the blocks, and the latter type withdraws the interior cores laterally. The above fairly covers that general type of machines in which blocks with interior cores are manufactured by tamping. You will note that but slight structural differences obtain, the diversity being more in the line of labor-saving devices. All contemplate the use of hand or automatic tampers, and hence neither wet nor medium mixture may be used. If this is attempted, the mass will squash under the blows of the tamper, while if comparatively dry it will pack to an extent sufficient to enable the block retain its shape while being carried (on the bottom plate) to the curing yard. Subsequent sprinkling is relied upon to secure additional crystallization. The best practice does not admit of placing such blocks in the wall under twenty days. While some manufacturers claim that coarse material, either gravel or broken stone, may be advantageously used under this process it has never been my good fortune to see this practice followed in commercial manufacture, and I believe sand and cement to be best adapted for use in the machines already mentioned.

Next in order we have the wet or poured process, which is characterized by sheet iron molds in which a fluid mixture is poured.

Either fine or coarse aggregates may be used with equal facility. The paramount ideas of this process are that a copious admixture of water causes the cement in fluid state to thoroughly permeate the aggregate and completely coat every particle thereof, and that such immediate and plentiful application of water secures a thorough crystallization in the initial set. There can be no question about a block so produced being both strong and durable, though there is some doubt as to the uniformity of that strength on account of the gravitation of heavier particles to the bottom of the mold. By the use of porous molds one manufacturer aims to avoid the porosity in the block due to an excessive amount of water creating voids by subsequent evaporation. The chief objection, however, to this process appears to lie in the fact that the block must remain several hours in the mold before attaining sufficient firmness to retain its form. Hence, an unreasonably large number of molds is required to produce a reasonably large output.

We have yet to consider the medium or pressed process, in which from seven to eight per cent. of water is used, and a considerable proportion of gravel or broken stone. As this process is comparatively new the systems based on its principles are less numerous than those under the processes previously considered, but I have found a considerable number of factories turning out a satisfactory product. As the pressure is simultaneously applied to every portion of the block, the difficulty mentioned in using a wet or medium mixture under tamping is obviated. On the one hand, this process eliminates the time consumed in tamping under the dry process; on the other hand, it eliminates the time consumed in setting in the molds under the poured process. It may fairly be said to partake of the nature of both, inasmuch as the amount of water in the mixture is sufficient to flush to the surface under pressure, and the blocks are afterward kept thoroughly saturated with water for a week before going into the wall—thus securing both the initial set and subsequent crystallization. The application of pressure necessarily eliminates the use of interior cores, and hence blocks are made in the "T," "E," "U," or "L" shapes mentioned in a previous paragraph, the molds providing for adjustment to all widths of wall by shortening or lengthening the arms of the blocks. The best results under this process appear to be obtained by pressing the block with the face up, for two reasons: First, the pressure applied in this way insures a hard, dense and comparatively impervious face; second, it affords an opportunity to first shovel the coarse concrete into the mold, and lastly (before pressure) to apply the rich face matter, which, under a heavy pressure, becomes well bonded with the body of the block.

Geo. H. Crafts.—There are three general systems of filling and

compacting the mixture into the forms desired; the pouring, tamping and pressure systems. In the pouring system, the concrete material in a wet condition is poured into the box or mold, great care being taken that the mold is completely filled in all parts, and particularly in the angles and corners, and that no air holes are in the material. The one-piece block is the block generally used in the pouring system of work. In the tamping system, which is the one most in use at the present time, the material in a damp condition is thoroughly tamped by hand tampers as it is put into the box, and especial care has to be taken that the edges and the corners are thoroughly rammed. The one piece block in multitudinous forms is the one generally used in this system. In the pressure system the material, which is in a damp condition, is pressed by hydraulic pressure, or pressure secured by toggle joints or other mechanism, into the box. Hydraulic pressure gives the heaviest or most exact pressure as the amount of pressure is shown exactly by a gage attached to the machine, and is the same regardless of the amount of material in the box. With the toggle joint machines, the pressure is more or less indeterminate, depending on the amount of material put into the box. The two-piece block is the one generally used in the pressure system, although the one-piece block can be made.

G. W. Robertson.—Too much care can hardly be given to the selection of a block machine, as upon the machine largely depends failure or success in block making. Aside from the fact that a majority of those engaging in the manufacture of blocks do not have the necessary capital to purchase and outfit a plant with hydraulic machinery, I do not believe the results obtained from the use of such an outfit justify the outlay either as to amount or quality of blocks made. Taking into consideration the fact that the pressure applied is for but a fraction of a minute, and that to a material in what might be called practically an air tight box or mold, and I believe the result will be found to be a block with two surfaces more or less compact, while the main body of the block is filled with air channels, where the air has been suddenly expelled or compressed, giving a block that will readily absorb moisture. Select a machine that will give varieties of the most salable size blocks. Get a machine with as few cogs, gears, springs and levers as possible, for you will find all such not only limit the life of the machine, but are liable at any time to get out of order from clogging with concrete. Do not get a machine standing too high, as then you will either have to build a platform for workmen to stand on or they will be working at a most decided disadvantage. Prefer also a machine using removable cores, as not only are they less liable to catch or stick when coarse material is used

for backing, but are also more quickly handled than machines with fixed cores. Prefer again a machine in which blocks are made face down and after being made are revolved, say, one-fourth to rest on pallet when machine is opened. Face, side and end plates should be accurately machined so they may fit properly, and not used just as they come from the mold, else you will always have trouble in getting your plates to fit, and also in having your blocks correct in size and shape. As to pallets for use with machines prefer wooden to iron, because of lower first cost and cost of maintenance. With common care wooden pallets will last nearly as long as iron, and their first cost should not be over one-sixth that of iron pullets.

Noyes F. Palmer.—Concrete blocks cannot be too good, and hence the heavier the machine and the more automatic its action and positive its movement, the cheaper the product. A machine must have adjustability to permit the manufacture of varied shapes. It must be the most favorable in functions to permit open top tamping and, like the flask and drag in the foundry, easily got at and handily manipulated.

G. W. Stevens.—A good way to judge a block machine is to find out how long it takes to set up and take apart the machine in actual work. Some of the points to be considered are these: Is it complicated and likely to get out of repair quickly? Are the castings light and easily broken? In the wet process the concrete should be wet enough to flow freely under the core and into the corners. By raising the end of the mold and letting it drop suddenly the concrete will be sufficiently settled. In the dry process fill in 2 or 3 ins. of concrete, give the first blows to the corners and the edges, and, finally, tamp the body. As soon as hard stop tamping. If tamped too much the layer will be smooth and be liable to cause a seam; the surface should be left a little rough so that the next filling will adhere to it. The last filling should bring the material above the mold so that it can be tamped solid and struck off with a straight edge.

H. H. Frantz.—The first things needful are "molds" or "forms," of which hundreds of patented articles are now on the market, but fortunately these need not be expensive, nor patented, nor is machinery at all necessary or essential; what is needed is a simple steel mold or form. This will consist of only four pieces of steel plate, say $\frac{1}{8}$ -in. thick, two sides and two ends, with the edges stiffened by riveting thereto steel angles, and arranging the angle joints so that these can easily be connected, and disconnected and firmly clamped; the inner surface should be perfectly smoothed. The size will of course depend on the size of block that may be desired; a block 10 ins. thick x 10 ins. high x 27 ins. long would be fair. Of

these molds a number must be provided, and with each there must be a smooth wood bed plate, say 12 x 30 ins. long, having a true smooth surface. The next requisite is a "core" (that is, a form of wood or metal) to be laid inside the mold, to form the hollow space in the block. It may be of any desired form. The block may have one or more hollows, extending through the block, from side to side, but their size should be such as will leave the walls or shell of the finished block of sufficient strength, from $1\frac{1}{2}$ ins. to $2\frac{1}{2}$ ins. thick, and their shape must be such that, after the cement block has been formed, it can easily be withdrawn, without disturbing the material of the block, usually in two parts, half to draw out from either side.

U. G. Hayne.—I can see no special object in making a concrete brick the same size as an ordinary clay building brick, except that of force of habit. I will not, therefore, consider that form of block more than to say that it can be made and laid the same as ordinary brick, but there is no saving in cost of laying in the wall over that of laying brick, which is quite an item in using concrete blocks. It may be that in some localities the call for blocks the size of brick will be such that a machine for making them will be a valuable addition to the plant. Then there is the choice between the machine in which the concrete is permitted to set in the mold, having the concrete wet enough to pour, and the one that uses the concrete of such wetness that the molds can be stripped from the block immediately, and the process of filling repeated.

While the point in favor of employing the make of machine that uses wet flowing concrete and permits it to set in the mold is a good one, it is more than balanced by being compelled to have so many molds to do the work with. Just as good results can be obtained with the machine using material of such wetness that it will stand to have the molds removed immediately.

Where reinforcing prevents the use of good tamping, or where the surplus water can be quickly drawn off, are the only cases in which I would sanction an excess of water in this class of construction. The simplest made machine with the least gearing and parts to get out of order will give the best satisfaction. On account of the danger of jarring the block, while handling it, after taking it from the machine to the place where it is to be cured, I would favor the machine that is taken from the block, after the block is in place for curing. The strength of the concrete can be much weakened and the block still hold its form, or the stone may be checked and the harm not noticed at any time, and thus result in making a poor block.

Machine or power tamping in a large plant should be all right, though, as I understand the situation, the power tamping machines

are not all the success that they should be. A pneumatic tamper handled by hand in a similar manner as the pneumatic riveter is said to be giving good satisfaction. On account of the expansive quality of air, the pressure made block is somewhat weakened by the expansion of the air in the stone when the mold is taken from it. I know of no machine of the pressure type that is a good block maker and believe this to be the reason.

This brings the question of the machine down to the one that can be easily carried, and to hand, or pneumatic, tamping. Add to this the ones that the makers are willing to furnish a copy of any patents they may have, and the makers' ability to prove that they will protect the purchaser in his rights, and the machine deal is ready to close. A machine with a patent on it is not of as much consequence as the features of the block and air spaces that are patented. In a wet country the double, staggered air spaces are more apt to make a warm, dry wall.

As to the speed of operation of a machine, there are few if any machines but that will make as many blocks as material can be tamped into them and taken out. Expressed in other words: they are limited only by the skill, dexterity and handiness of the crew handling them, and a gang of three men should be able to make from one hundred and twenty-five to one hundred and fifty blocks, of an average size of 8 ins. high by 9 ins. wide, by 2 ft. long, in a day of ten hours.

A machine guaranteed by a good, reliable company should be considered above one not so warranted, other things being equal. Though the cost of compelling the making good of the guarantee makes it of uncertain value. The only feature of exclusive rights that has any real merit is the one where the patent applies to some good feature of the structure of the block and not to the machine. There are so many machines of practically the same price and capacity that the exclusive right to use a certain machine without a block patent would be of little if any value.

H. G. Richey.—After deciding on the location of the plant, then will come the selection of machines or molds. This is a matter that must be left to the party who is to operate the plant; for different people prefer different machines or molds. He should visit the different plants in operation and see the various machines at work, and then after making all the inquiry he can about them select the one that most favorably impresses him.

There are quite a number of machines on the market at the present time, and all are turning out about the same quality of block. So far as quality is concerned, it is not so much the machine or molds as the materials used, the proportions in which they are mixed, and the manner of using them, that determines the quality

of the block. A person in selecting a machine should select one which is not too complicated, and which is as simple as possible in its operation.

Some manufacturers of machines, in addition to selling their machine or molds, are selling exclusive territory for the use of the machine. The writer considers money paid for the right to use any particular machine in a certain territory is money thrown away, for there are so many different makes of machines on the market that the buying territory for the use of any particular machine will not give the purchaser the exclusive right to manufacture concrete building blocks in that territory. Some other party with a different make of machine will step in, and turn blocks equal to the ones made by the person who paid his money for exclusive territory. Thus the writer would be adverse to paying money for territory, but would take the money thus saved and purchase additional molds for making a larger variety of blocks.

The location and amount of business contemplated will also have to be considered when purchasing a machine. If it is not expected to do a large business a set of ordinary molds may be sufficient, but in another locality where there will be a large demand for the blocks a larger number of molds or machines will be required.

CURING MOLDED BLOCKS.

Geo. H. Crafts.—After molding the next process in the proper making of blocks is the curing. This process is one of the most important in the manufacture of first-class blocks, although, as a usual thing, no attention at all is paid to it. Most block makers consider that the block is made as soon as it comes out of the mold, and they put it out in the sun or in any old place where it is handiest and pay no attention whatever to the curing of it. Any concrete material to attain its greatest strength and have the best appearance must be properly used, and this curing consists in keeping the material in the shade and in a wet condition for a number of days after it is made. If concrete dries out immediately after making, the action of the cement is deadened and the concrete is crumbly and weaker than if kept wet until the cement has had full time to harden. All good authorities recognize this fact and proper means for the curing of all blocks should be a part of every building block plant. The blocks should be kept in the shade and thoroughly wetted for a week or ten days in order to receive the proper curing.

U. G. Hayne.—After the block is safely set it should be gently sprayed with water, care being taken not to have the spray of such force as to disintegrate the face of the block or mar the corners. After ten or twelve hours there is little danger of the block receiving too much water. The intelligent care used in curing

molded concrete work has almost as much to do with attaining its ultimate strength as the quantity of cement used. The early drying of the block will have a tendency to dry out the corners before the initial set is fully completed, leaving them with little strength and likely to crumble at a touch. Plenty of water for about ten days is what the work needs after the first sprinkling is given.

Joseph Babiczky.—Curing of the blocks is one of the most important processes of their manufacture, and must be watched very carefully. In summer the heat and in winter the frost is very injurious. In summer after the blocks have set so far that sprinkling does not hurt them they must be sprinkled over and over again. A boy with a watering pot which is equipped with a rose spray and which sprays the water in a uniform stream is one of the best devices for small and medium size plants. If there is city water under pressure it serves well, but I would suggest in the first 48 hours the exclusive use of the watering pot, as the pressure of the city water can easily injure blocks in the early stages of hardening. Apply water in abundance.

H. G. Richey.—Concrete blocks should always be cured by wetting or sprinkling them with water. Blocks which have sharp corners or arrises or any sharp projections should be given special care to keep these projections moist and prevent their drying too rapidly. A number of block manufacturers have failed to produce ornamental blocks with sharp and distinct lines, the principal reasons being that the mixture used was so poor and the projections or ornamentations of the blocks were allowed to dry too rapidly. Blocks as soon as taken from the molds should be placed in the curing room or shed, which should be built so as to exclude all sunshine or draughts of air. As soon as hard enough, which will be in about ten hours, the blocks should be sprinkled lightly with water and covered with a wet cloth or burlap; they should then be wet four times daily for about seven days, and should not be removed for use until they have attained an age of about 15 days.

FACING AND COLORING.

H. H. Rice.—I now challenge your attention to that much mooted question of body and facing, as well as various forms of face and colored blocks. Eliminating face matter from your process of manufacture, you are compelled to make your entire block of such material as will produce the face you desire. That is to say, if you wish a rich face your entire block must be unnecessarily rich in cement. If you wish a fine face your entire aggregate must be of fine sand, and result either in a loss of strength or in the use of an inordinate proportion of cement. A standard argument against facing is that it does not increase strength; certainly not.

Though face matter contains a much greater percentage of cement than does the body of the block, yet the aggregate of the face is very fine sand and hence possesses no greater strength than that obtaining in the body of the block through the use of a smaller percentage of cement with coarser material in the aggregate. Now, do you wish to use a similar composition throughout the block, with consequent loss of strength unless the amount of cement be abnormally increased? Certainly not. What then? Do you desire the face of your block to be of coarse material? Certainly not in a quality of blocks to compete with pressed brick and cut stone. The opposition to facing has largely arisen from the old style of mold in which faces are formed by the upright sides, and in which there is no device for facing otherwise than by the use of a partition. A popular demand always brings forth some remedy for any existing evil, and this fault is now overcome in various ways in various machines. Some now make the face on the bottom of the mold, some tilt the mold at an angle in order to put in the face matter first, some make the two-piece blocks with face up, putting the face matter in last and then applying pressure from the top. Of these various machines more in their order, but the fact I wish here to establish is that the various devices now in use for facing prove beyond a doubt that what the people want, and what they will have, is a strong and durable concrete block with a beautiful face. And here I would also firmly impress this truth, that the face and the body of the block must be made at one simultaneous operation and the face matter must be so imbedded into the coarse concrete that it becomes an integral part of the block, and there must be no distinct line of cleavage between the face and the body. I wish you would memorize that; it is perhaps the most important sentence in this paper, and the number is legion who have dearly paid to learn this truth.

Now, as to various forms of face, the smooth even face is always elegant, but if without contrasting ornamentation it becomes monotonous. The pitch face, commonly called "rock face" by all block makers, is to-day the most popular design, principally from force of habit. I cannot believe that it will ultimately endure, as it nearly always appears to be what it is—an imitation. When the manufacture of concrete blocks was in its infancy, a man whose name is known to very many readers of this article as an eminent authority on cement matters, remarked to me, "What you want is a face that will survive, and that face will be chiseled or ribbed with a bevel edge, because it has a genuine look." He was right. That is the face that is daily growing in favor. The popular demand of the day is for genuineness. That is destined to be the face of the future. That is the face which will get business, which

will keep business, and which will increase business. Then there are various ornamental faces; nearly every plate manufacturer produces a greater or less variety. Into the merits of these I shall not go. Prepare yourself with a reasonable variety, in order to meet the demand, but don't get into the "gingerbread" habit—it lacks elegance. And don't, without advising to the contrary, allow a customer to select a design of which he will tire in a month.

Now, as to colored facing, it is simple. Almost any color may be produced by mixing dry mineral coloring matter with the face matter. Vegetable colors should never be mixed with cement. Reputable manufacturers now produce colors from iron pigments, especially adapted for this purpose, furnish them at reasonable prices, and supply complete instruction as to mixture and methods. A quarter or three-eighths inch face properly colored and properly applied will produce a beautiful stone practically unchangeable and everlasting.

G. W. Stevens.—In making colored blocks the following colors may be used: The proportions given should vary according to circumstances, different materials giving different colors. There is one coloring matter that is a benefit—that is lampblack; all other colors are more liable to be an injury than a benefit. In mixing it is best to mix your coloring with the sand. The barrel to be used for measuring should be the size of a cement barrel. To obtain blue, use $3\frac{1}{2}$ lbs. of ultramine blue to one barrel of sand; dark blue, 1 lb. of Germantown lampblack. For red use 10 lbs. violet oxide to one barrel of sand; if a small amount of lampblack is used the color will hold better but will be changed. For buff, use 5 to 7 lbs. of yellow ocher per barrel of sand, and for brown use 6 lbs. of brown ocher to a barrel of sand.

By using the coloring judiciously the blocks will be made so that no two stones will be alike. The way to do this is to mix and wet two different kinds of facing; they can be both colored or one can be without coloring. Spread out one mixture an inch or two thick, then put the other on top of it, give the two a light turning and use as facing. Another way is to put a little of one mixture and then a little of the other into the mold.

H. H. Frantz.—The coloring of concrete blocks can, as a rule, be accomplished only at the expense of loss of strength, with the possible exception of red, which may be secured by the addition of finely ground oxide of iron mixed with the facing cement.

H. G. Richey.—In making concrete blocks the manufacturer should be able to imitate or match any of the various natural stones; this can be done by using the proper coloring materials. All coloring materials should be the best to be obtained, and should be used carefully, just enough being used to give the desired shade. The coloring

material should be measured very carefully so as to get every batch of mortar or concrete of the same shade. The following is a list of the most common coloring materials used and the amount to be used with a barrel of cement. Of course, these quantities will vary according to the color of the cement used and the color of the block desired. Usually coloring materials will lessen the strength of the mortar or concrete, so no more than necessary should be used; this is especially so of the ochers. To color black use 45 lbs. of manganese dioxide to a barrel of cement; brown, 25 lbs. of best roasted iron oxide, or 15 or 20 lbs. of brown ocher per barrel of cement; blue, use 19 lbs. of ultramarine to a barrel of cement; buff, use 15 lbs. of ocher to a barrel of cement, but this will greatly reduce the strength of the block; green, use 23 lbs. of greenish blue ultramarine to a barrel of cement; gray, use 2 lbs. of Germantown lampblack (bone black) to a barrel of cement; red, use 22 lbs. of raw iron oxide to a barrel of cement; bright red, use 22 lbs. of Pompeian or English red to a barrel of cement; purple, use 20 lbs. of Princess metallic to a barrel of cement; violet, use 22 lbs. of violet oxide of iron to a barrel of cement; yellow, use 22 lbs. of ocher to a barrel of cement. Ultramarine is one of the best coloring materials, as it does not affect the strength of the cement. Germantown lampblack is also good on account of the small quantity necessary to give a good color. Do not use common lampblack or venetian red, as they are liable to run and fade. In coloring blocks the wet mixture should be colored several shades darker than that desired in the finished block, as the wet mortar looks darker to the eye (owing to the gloss of the water) than it really is. Concrete blocks should not be too dark as this is contrary to nature; all natural stones are of a light color or shade, thus in making a concrete block it should be given tone rather than color. The sand used for the colored mortar should be perfectly dry, and the cement, sand and coloring matter mixed thoroughly before being wet. Various shades and colors can be obtained by the use of different cements; for instance, a blue cement used in connection with light colored sand will produce a light blue block. Experiments should be made with the various sands and cement to be obtained so as to know what colors of stone can be produced without the addition of coloring matter.

Joseph Babiczky.—Facing and coloring for cement blocks have been much discussed. I can see no reason why rock face has been used so much. Concrete blocks are too fine grained and too uniform in color to have such a face applied to them. Smooth or flat tooled faces are more suitable to the material. Facing blocks with an extra rich mixture to make them waterproof results in too smooth a surface; if any facing is used it should be made with crushed granite or marble. This gives a fine effect and does not cost much more than

colored faces, which can be obtained by adding different mineral colors to the concrete.

U. G. Hayne.—In using coloring matter, mineral colors are the safest. Take the proportion of the coloring decided upon and mix it and the cement thoroughly, then add the necessary sand and mix all together until of a uniform color, then add water and mix until of a uniform color and of the wetness desired. For a black stone, take 1 cu. ft. of cement and 2 cu. ft. of sand, to this add 3 lbs. of excelsior carbon black; for a gray stone add 1 lb. of excelsior black to the above quantity of sand and stone. Using the same quantities of cement and sand add for the following colors: Dark blue, 4 lbs. ultramarine blue; brown, 4 lbs. brown ochre; bright red, 7 lbs. English red; red, 5 lbs. violet oxide of iron (raw). Coloring matter should be used sparingly, as much of it is detrimental to the setting of the cement.

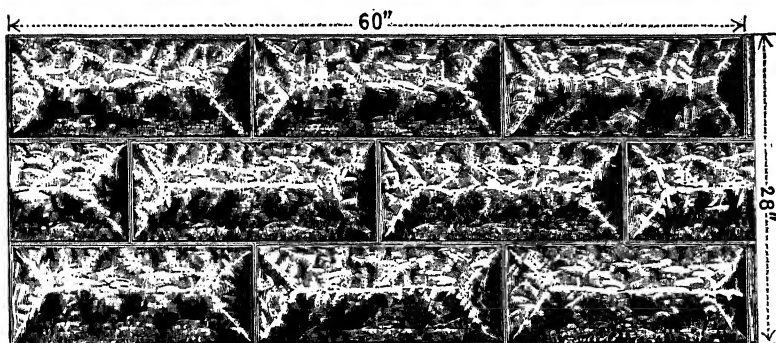


FIG. 7. Stamped Metal Forms for Pitch-Faced Wall Blocks.

ORNAMENTAL WORK.

H. H. Rice.—Of ornamental work I would say, leave it to a specialist. It is possible to produce most beautiful figures in cement work by simple processes, but poor ornamentation is an abomination, and a high degree of skill is required to obtain effects really artistic. In every manufacturing center you will find factories exclusively devoted to this branch of the cement industry. If you value your peace of mind or care for your profits you will, until you have acquired skill through long experience, give to such a factory the contract for that part of your work.

H. G. Richey.—For making special molds for rock face work sheets of stamped metal in imitation of rock face can be procured at little cost, as shown by Fig. 7, and this can be cut and shaped to make any size block desired. This metal can be procured in blocks of various sizes and also in lengths of 5 ft. and from 6 to 12 ins. in width. These stamped shapes can also be procured for making

piers, porch columns, etc. Fig. 8 shows stamped metal suitable for this work.

Molds for the nosing and molding of steps can also be made in sheet metal, and a step of this kind will look much better than a plain one. For making molds for cornices, moldings, etc., stamped and bent sheet metal can be used as shown by Fig. 9.



FIG. 8. Form for Pitch-Faced Column Blocks.

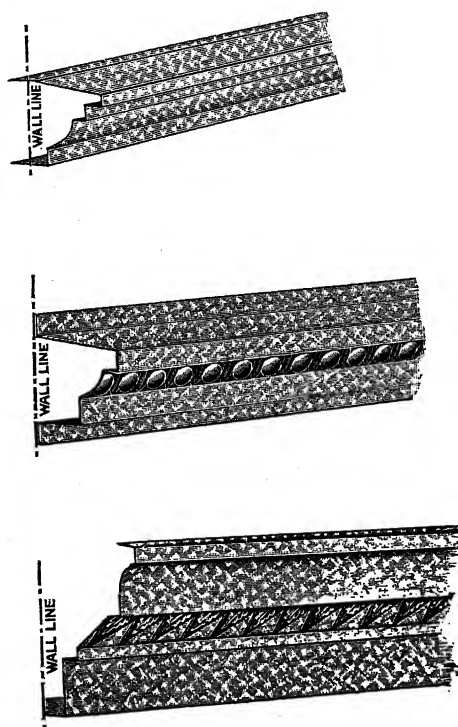


FIG. 9. Form for Cornice Blocks.

These members can be got in any size and shape desired and up to 8 ft. in length. Circle molds as shown by Figs. 10 and 11 are also made in stamped or spun metal, and make excellent molds for bases and caps of columns.

Spun ballusters in sheet metal can be cut apart and used for

molds for casting cement ballusters. In cutting the molds for circular work they should be cut in three pieces so as to be more easily removed from the cast stone.

Special molds for ornamental work of all kinds can be made from stamped metal. The metal when stamped in one piece can be used direct as a mold for ornamental work, or if the design is made up of several pieces of metal soldered together a mold can be made by taking an impression direct from the face of the metal ornament with a glue composition. In this way a mold can be made to duplicate any ornament desired. This glue mixture for making molds for plaster or cement ornaments is made as follows:

Take the very best glue to be obtained, place it in cold water a night, the next morning take it out; when it will be found to be swollen. The water it has absorbed during the night is sufficient to melt it by heat; then mix as much glycerine with it as you had glue and keep the vessel containing them in a steam or hot water bath till the water is about evaporated, and till there is left as much in weight as the weight of the dry glue and glycerine taken together amounted to. This will make a compound of glue and glycerine which will never dry, and a mold of it can be remelted and used over and over again.

The most intricate design can be made in these molds, and with a little practice the mechanic will be able to turn out ornaments and work to conform to or duplicate any architectural design and add a great percentage to the appearance of any building he may erect or furnish the blocks for.

Molds can be made in cement for plainer ornaments or moldings; the cement can be poured on the original and when hard can be removed, and this reverse impression of the ornament or molding can

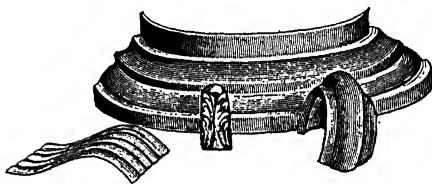


FIG. 10.

Stamped Metal Circle Moldings for Column Cap and Base Blocks.

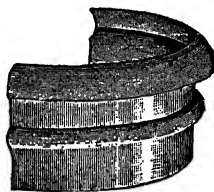


FIG. 11.

be used as a mold in which to cast the ornament. Before pouring of the cement the original ornament should be given a coat of linseed oil to prevent the cement from sticking.

After the cement mold is hard it should be given a coat of paint made by dissolving asphalt with turpentine or benzine. This will give the mold a smooth surface, which, if coated with a soap solution will not stick to the cast.

In making molds or ornamental blocks several can be made along with the ordinary day's work, and in this way will not require a large number of molds for each design.

Figs. 12 and 13 are specimens of stamped metal suitable for orna-

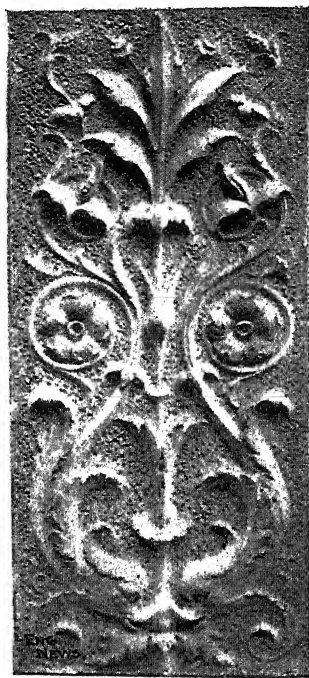


FIG. 12. Stamped Metal Form Suitable for Ornamental Block.

mental molds; and Figs. 14 and 15 show a pilaster capital and a panel made of cement cast in glue molds as described.



FIG. 13. Metal Form for Ornamental Block.

Cement moldings can also be run in long lengths with a mold similar to that used in running stucco or plaster cornices; then the molding can be cut into the desired lengths.

To make a success of the concrete block business the proprietor must have mechanics who will be able to make any special mold desired to reproduce the designs and ideas of the architect.

The past use of concrete blocks has shown and developed little along this line, nearly all of the work done in the has been confined to the product of machines and to an imitation of rock face work, and this is an imitation of the cheapest and common class of stone work.



FIG. 14. Concrete Panel Cast in Glue Mold.

The reason of this has been that the majority of the molds furnished with the various machines have been for this kind of only.

The successful block manufacturer must break away from sameness of production and produce blocks in imitation of the best class of stone work. It costs no more to make blocks of this than those imitating the most common work except the cost of

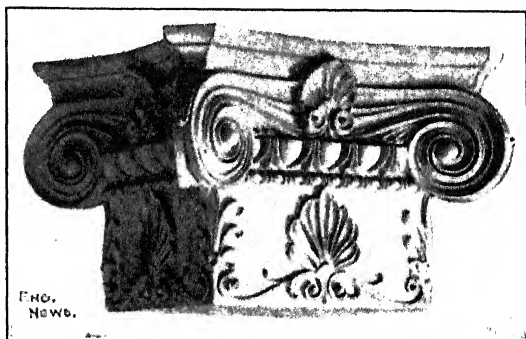


FIG. 15. Concrete Column Capital Cast in Glue Mold.

molds and perhaps a little extra work, but this will pay in the

Take blocks made in an ordinary box mold, with the face troweled smooth as for sidewalks, and you have a good imitation of real stone and also a waterproof block; water does not go through a sidewalk simply because the face or top is troweled smooth and made of a strong mixture of cement. To float the block off v

cork or wooden float and leave it a rough sand finish gives a very desirable effect.

A tool can be made of corrugated metal or of cast iron in the form of a trowel, which can be used on the face of the block and which will give a correct imitation of droved work on cut stone.

Blocks finished in this way are very pleasing to the eye, as the small corrugations (about $\frac{1}{4}$ -in. apart) take away the gloss or smooth surface from the stone.

In the operation of a concrete block plant there will continually develop new ideas for making of molds and of ornamental blocks and the man who is always on the alert to adopt new ideas which will assist him in turning out varied designs of blocks will be the one to succeed in the business.

The cement or concrete block houses of the past have not been designed by architects, but as a rule have been merely four walls built up and a roof put on them; but the concrete block house of the future will be designed by architects. Architects have been slow to take up concrete block construction for this reason, they have not been able to get their designs and ideas reproduced in the concrete blocks. It will thus be seen that the man who equips his plant in such a manner so as to be able to turn out blocks according to, and which will conform to the architects' sizes and drawings, will be the man to make a success of the concrete block business.

H. H. Frantz.—Ornamental faces may be had at but little additional expense by procuring stamped patterns of thick oiled cardboard, such as are employed by wall decorators in all cities. By placing one of these patterns in the bottom of the mold and filling the concrete on top if it, its duplicate will be obtained on the block face after washing the cardboard off with hot water. Another very pretty effect can be easily produced by the employment of an ordinary sheet of paper and a stencil. Lay the stencil on the paper and apply a brush coat of glue, the pattern of the stencil will be produced in glue on the paper. On the wet glue sprinkle granite or marble chips or crushed glass of bright color and after the glue has become dry shake off all loose particles. Lay the paper face up in the mold and fill above with concrete. When the block has hardened and the paper has been washed off, the pattern will appear in marble chips or what not.

SPECIAL BLOCKS.

H. H. Rice.—I shall now consider the manufacture of a class of specialties which will greatly embarrass the operator if he be not prepared to meet the issue. I refer to such portions of a building which may fairly be grouped as sills, lintels, caps, coping, belt courses, arches and key stones. No machine of which I have knowledge which may be truly characterized as a concrete block machine,

capable of satisfactorily producing these parts except in most limited sizes and designs. It is true some have attachments and others have cumbrous and unwieldy auxiliary machines of limited adjustability. In my opinion these attachments and auxiliary machines are made solely to sell, and do not embody the fundamental idea of mutual benefit as between manufacturer and operator. I have had a laborer, unskilled in carpentry beyond the use of saw and hammer, prepare from S-I-S boards molds for these things with most excellent results. They may be adjustable, too. The principle of their making is explained in the mold first described in the preceding section. If ornamentation is desired it is easily secured. If a molded belt course is needed, put a piece of stock molding in the bottom. If the demand be for arch blocks or keystones, ascertain the radius and cut the boards at the required angle. Put your face matter in first and back with concrete as wet as can be tamped. If sills or lintels are over 4-ft. in length, reinforce with an angle iron embedded in the concrete.

H. H. Frantz.—The production of special blocks is simply a matter of pattern making. Sills, caps, keys stones and all the ornamentation of an architect's design can be readily executed in wooden molds.

WATERPROOFING.

U. G. Hayne.—There are localities where waterproof walls are very essential, while other places where the rainfall is very small have very little need of such a wall. Where one is required, good results can be obtained from a waterproofing mixture of alum, lye and cement, to be used as a wash, and made of the following proportions:

Dissolve 1 lb. of concentrated lye and 5 lbs. of alum in two gallons of water, care being taken to have every particle dissolved. Heating to near the boiling point will quickly insure this without injury to the mixture. This constitutes the "stock" and may be mixed in any quantity. To one pint of the stock add 10 lbs. of cement, thinning out with water until the mixture spreads easily and well on the blocks or walls with a calsomine or whitewash brush, filling all the pores in the face of the block. This is satisfactorily done when it lathers freely under the brush. Usually one pint of the stock put into a 12-qt. pail and 10 lbs. of cement stirred in, with enough water added to well fill the bucket, makes the wash about right.

Much depends, however, upon the condition of the surfaces to be coated, as to how dry they are. If too dry, wet them down with a spray or a brush ahead of the waterproofing, the object being to apply the wash as thin as practicable without running, rubbing the wash well into the block with the brush. The wash should be applied to the face of the block that is to be exposed in about

three or four days after it has been made, and while the block is being kept wet in curing, as a few hours are sufficient for the wash to harden enough to stand a spray. The wash is not satisfactory on old work, and should be applied while the block is under cover from the sun and where it is moist. Otherwise too rapid evaporation of the water in the wash will leave the cement without the necessary moisture to set it and leaving it so it can be brushed off. The wash should never be applied too thick or it will be liable to scale off similar to paint that is applied too thick.

One part "stock" and about thirty parts water can be used for wetting the one part cement to two parts sand mixture that the blocks are faced with, instead of using water, with good results. This will leave the face of the block as it comes from the mold without the mark of a brush on it.

I have seen this wash used for over twelve years, and in no instance, where it has been applied correctly, has it failed to make the surface waterproof. In fortification work I have seen sand fills sluiced over the top of concrete surfaces under which were rooms and passages, and the water stood for weeks above them without a sign of any of it coming through. Have used it on cable tanks with complete success. Two tanks constructed seven years ago, and made to hold 6 ft. of water, have been in use continually since that time and lose no water except by evaporation. In this case two coats of the wash was applied to the inside and bottom of the tanks, and also to the outside walls. The concrete was first plastered with a coat of one part cement to two parts of sand mortar.

A large store house constructed eight years ago, with solid walls 1 ft. thick, in a climate where the annual rainfall is about 80 ins., was given two coats of the wash under the same condition as the cable tanks, and it has been dry at all seasons since, with no sign of moisture on the walls. In addition to its waterproofing properties this wash tends to prevent fungus growth on, or discoloration of surfaces coated with it. It thoroughly closes the pores of the plaster and insures dry walls.

A block faced with a mixture of one part Portland cement to two parts clean sand, well tamped, is nearly waterproof, and if correctly cured will answer in many localities without waterproofing. The facing on a correctly made block is in no danger of peeling off.

The Sylvester process leaves the surface of the concrete looking practically the same as when taken from the molds, and in some instances this is much to be desired. The method of mixing and using which is as follows: Dissolve $1\frac{1}{2}$ lbs. of castile soap in 1 gal. of water; also dissolve $1\frac{1}{2}$ lbs. powdered alum in 4 gals.

of water, when the surface is dry apply the soap wash at boiling heat with a brush, but do not froth the soap. After the soap wash is thoroughly dry apply the alum wash the same way at a temperature of 70° F. The applications should be made twice to secure perfect impenetrability to water.

The alum and lye wash sprinkled, immediately after applying, with granite dust, or, in fact, with any very fine sand or stone dust, will make the block look very much like natural stone, though I do not see any very good reason why concrete should not be able to pass on its own good looks if dressed up as it should and can be.

A wall can be painted with an ordinary linseed oil paint and made waterproof for a time the same as a brick wall is sometimes painted, only the paint should not be applied for at least six months after wall is made, as the paint will not stick sooner. Would not make a custom of painting block walls.

COST.

U. G. Hayne.—As the cost of the materials varies with each locality, it will be necessary to assume prices at which materials and labor can be purchased, and which can be easily adjusted to suit the location. The prices here given are all higher than in most parts of the country, but prevail in this vicinity. Cement, \$2.50 per barrel of about 3.4 cu. ft., or 4 cu. ft. measured loose; sand, \$1 per cu. yd.; labor, \$2.00 per day of nine hours. That incidental expenses will amount to about 4% of the total cost of the blocks, which is about right for a small plant, but a little high for a large one.

The cost of the blocks that will lay the same amount of wall as 1,000 ordinary sized building brick is about \$7. This is calculated with a one part cement to four parts sand mixture, and figuring out 25% for the hollow spaces. Any other mixture can be figured out with this as a base. For laying blocks of about one to two cubic feet volume, it takes about one-fourth the mortar and about one-third the labor that it takes to lay the same space with brick. The cost of special blocks, to comply with the requirements of the plans will vary according to the difficulty of making them, or from two to four times as much as for ordinary blocks.

I understand that in some cities the building ordinances permit a hollow block wall to be somewhat narrower than a brick wall would be required for the same space. When in considering the cost of a block, it must be remembered that there is practically no difference in the cost of a plain, panel or rock faced block, and that there is considerable difference in the cost of brick, pressed brick and stone.

At the figures given above, a 12 in. wide, by 24 ins. long, by 8 in. high, block will cost 19 cts.

Joseph Babiczky.—The cost of manufacturing blocks varies very much in different localities, but can be calculated near enough before anybody goes into the business of manufacturing blocks. My experience is that one part cement and five parts sand properly mixed, tamped, handled and cured gives as good blocks as any common building stone. Or if suitable crushed stone can be obtained, then 1 part cement, $3\frac{1}{2}$ parts sand and 6 parts stone is also a good mixture, supposing that the sand is not too coarse and the crushed stone has a maximum size of $\frac{1}{2}$ in. down to dust. I will give examples of how to calculate the cost of manufacturing. Suppose a small plant started with four hand machines.

With four machines 400 blocks can be handled daily. The blocks are supposed to have the following dimensions: 24 x 8 x 8 ins., and contains, after deducting the hollow spaces, $\frac{1}{2}$ cu. ft. of concrete.

Mixture: 1 part cement and 5 parts sand; necessary for 1 cu. yd. of concrete, supposing that a barrel of cement = 3.5 cu. ft.

Cement 27/5 : 3.5 =	1.54 bbls.
Sand	1 cu. yd.

Total expenses for 400 blocks daily capacity by using 400 x 0.5 = 200 cu. ft. = 7.4 cu. yds. concrete are:

Materials:

Cement 27/5 : 3.5 =	1.54 bbls.
Sand	7.4 cu. yds. at 60 cts. = 4.44

Labor:

4 moulders	at \$2.00 = 8.00
2 mixers	at 1.50 = 3.00
1 water boy	at 1.00 = 1.00

Total \$36.94

or $\frac{36.94}{400} = \$0.925$ per block.

To this must be added the interest of the capital invested, maintenance of the machinery, tools, etc., office expenses, etc. This will make the average price about 10% per block.

BUILDING CONSTRUCTION.

N. F. Palmer.—The laying of concrete blocks is the duty of a stone mason, and calls for the same mortars and methods as with a stone or marble building, except that in the stone or marble structure the cutter and trimmer under the scaffold does the preparatory work, from measurements from the wall, while the concrete blocks come to the scaffold the exact size. A concrete block cannot be cut and fitted to the wall—at least, not on the outside—without breaking the skin or outside set without opening the entire inside of the block to moisture and dampness—the enemy of all stone buildings. Therefore, the problem for the mason is to lay concrete blocks so that the outside can be pointed up tight and true.

Foundations should not be made with either mortar blocks nor with brick. Brick foundations, unless treated on the outside, will always create dampness which will permeate the entire superstructure, whether of wood, stone, mortar block or iron. Concrete blocks can be used as foundations, but should be treated on the outside to prevent dampness, and the hollow spaces ventilated. Regular concrete of 1-3-5 in the usual forms are cheaper than molded blocks of any material for foundations. We have seen foundations holding up four-story brick buildings, made 1-3-5, and the 5 was gravel, not a broken stone in it. We should have preferred broken stone to round gravel. The best Portland cement should always be used in foundation work, no matter if of stone, brick or concrete in any form, but never use hollow mortar blocks in foundations.

Preparatory to the mason's work it is presumed that the architect's details have called for such units in the wall, and fractions to fit all corners, openings and stretchers as will fit the plan. Corner blocks are laid first, and from the center both ways the marks are made on the foundation by the use of a gauge showing the unit, its half, three-quarter and one-eighth size, etc. No blocks are to be laid on a course until this marking agrees with the plan. Mortar should never be spread within one inch of the outside of a finished wall, or in the center line of the block lengthwise of the wall. The outside one inch for pointing up, the center line to permit of longitudinal circulation of air to allow circulation of damp air from the damp side of a building around to the drier side. In pointing up the best Portland cement putty with stone dust, and a small percentage of hydrated lime should be used. In our experience we have seen several concrete block buildings faced with La Farge cement that had the dry appearance on all sides of the structure, because of this method of mason work. In that case, of course, the blocks were faced in the manufacture of the block, and were pointed up after completion. It is well known that La Farge cement is for inside fine finish, and the use of it on the outside of a building was an innovation. To our mind the skill of the mason builder and of the architect on this concrete block building is manifest. On the contrary, we have seen buildings erected under charge of this same architect and mason builder who failed to build a satisfactory structure in this same neighborhood with blocks that were not faced, that were cut to fit the wall, where double the number of blocks were made and half the blocks condemned as unfit, mistakes of the block machine man and lack of knowledge how to plan and how to build. The fact that the same architect and mason builder tried again with a different machine and erected an \$8,000 Queen Anne building and sold it as soon as completed, is proof that the industry only lacks skill of architect and builder.

Now, what can be done to a completed building made with mortar or concrete blocks to improve its appearance, or to remedy defects of face mix? Nothing can be done in such building to correct the unequal mortar joints caused by improper size blocks. The joints may be repointed, and the face may be recoated, which will improve the structure. And the manner of doing this can also be followed where the material was first-class as well as the mason's work, by a wash coat of Portland cement and hydrated lime. We have tried this, as well as a wash coat of alum water followed with soap water. The latter method can be done, and then a wash coat of Portland cement and hydrated lime. We have tried this on blocks we know were poorly made, merely to show operation of our machine, and we are satisfied that any concrete block building can be treated and made more impervious and of uniform exterior by a wash coat of 1 Portland cement, $\frac{1}{4}$ of hydrated lime used as a whitewash. In fact, we have treated chimneys exposed to great changes in temperature, and, in fact, leaky tin roofs, in same manner, and are surprised at the result. We give these experiments as the result of practical experience, and in block construction it is well to bring some of these practical experiments to bear in this new industry.

Geo. H. Crafts.—It is a great mistake for a building block manufacturer to try to compete with common clay, brick or wood construction in price, as to do it he has to make an inferior article which will eventually injure him and the business. Good blocks cannot be made as cheap as common bricks in most localities, and there is no use in competing in price with them. Concrete building blocks do not compete with common bricks, but with natural stones and pressed bricks, and where these materials are cheaper than good building blocks there is no need of a building block plant and it cannot be made a success. This will happen in very few, if any, localities, however, as the cost of quarrying and cutting and laying of natural stones is much more than the cost of making and laying building blocks. The qualities of good concrete blocks will often give it the preference over pressed brick or terra cotta at about the same prices.

Joseph Babiczky.—Most walls are constructed not only for direct vertical loads, but also to resist the lateral forces which act, if walls are high in comparison with their width. The ideal wall is the monolith concrete wall, and the weakest in construction are the walls built out of brick, as the many horizontal and vertical joints of a brick wall are the weak points in every respect, no matter how carefully built and bonded. The hollow concrete block wall has the advantages of both, without having their disadvantages as it is almost a monolith as usually laid in first-class cement

mortar. The face is uniform, can be made in any color or finish and also with architectural design. Offers can be made for building a house per square foot, but before starting the manufacturing of the blocks extra drawings must be prepared showing every block in the building. Then an index must be made, which shows the different sizes and the number of blocks.

The first thing is to prepare such plans. The architect (if any is engaged) lays out the plans for brick or frame building and his plans must be worked over for cement blocks. It is very simple work, notwithstanding it must be done very carefully. Every phase of manufacturing and also using of cement blocks must be taken into consideration in making advantageous and acceptable plans for this purpose. If possible, whole, three-quarter and one-half blocks must be used, and the use of different sized blocks makes the manufacturing of the concrete blocks complicated, and also building walls out of them, causing extra expenses. Corners, pilasters, etc., must be shown not only in view, but also in plan. The working drawings for the masons must be made clear and easy to read, as otherwise misunderstandings and delay in the work may easily result.

It happened in my practice that everything was in first-class shape, but I could not get any masons who could lay concrete blocks easily and with a fair amount of speed. I was obliged to watch them and not only see that the blocks were laid after the working drawings but that the wall went up straight, joints pointed up before the cement mortar hardened. Brick masons are not suitable for cement block setting, and they are too high priced, too speedy, and are not accustomed to lifting heavy weights and to do exact work. First-class stone masons are required, but they must also be very closely watched.

My opinion is that every block manufacturing plant must have not only the special workmen for the manufacturing of concrete blocks, but also those who build them in the wall. The organization of the concrete block manufacturers or the entire business world which is especially connected with using of cement for the different purposes, must take place without any delay. This is such an important branch now, and it develops with such immense rapidity, that an immediate organization of the partakers is indispensable. To protect trade, labor, and to guard the reputation of such an important business branch by a well-organized body, is absolutely necessary.

Now, often different unions make trouble. The brick masons are of the opinion that the wall out of concrete blocks can only be built by them, the stone masons are of the same opinion, and I think neither of these unions have the right to "butt in," and the

reason why they do is that they do not have to confront a strongly organized cement-working union.

Concrete blocks must be laid in good Portland cement mortar, 1 part cement and $\frac{1}{4}$ slacked lime, and $3\frac{1}{2}$ parts sand. First, cement and sand must be mixed dry thoroughly, then slacked lime added.

My experience has been that in summer often cement mortar is half set when the last third part of the batch is used up. The mortar mixers must be instructed and also watched very carefully, as they are mostly accustomed to lime-mortar, which can be used even after days have elapsed without any disadvantage. Let them make small batches and mix thoroughly dry, and after that wet same.

If late in autumn or early in spring, walls must be built out of concrete blocks; it is better to leave slacked lime out entirely, and use one part cement and three parts sand, as the night frost may destroy the cohesion of the cement mortar if it is not yet set. In hot summer days the blocks must be sprinkled over before set in the wall and the mortar made good and slushy, as otherwise the cement mortar will dry out before it hardens.

Avoid, if possible, any kind of work with cement in winter time. If unavoidable, be very careful. Never do any work under 25° above zero. Under 40° above zero the manufacturing plant must be heated. Be careful and do not use an open coke stove when you are working in a tent, as the gases which develop destroy the top of your tent in a short time. If the temperature is less than 32° above zero, the sand and the water must be heated for the block and also for the mortar. The frost alone does not injure even fresh cement concrete very much, but the alternating of frost and thawing loosen the cohesion and lessens the strength considerably.

I made an interesting experiment on this point last winter, when I was obliged to complete a very important structure as soon as possible. It happened that at noon the thermometer showed 40° above zero, and the next morning 10° below. My blocks, notwithstanding I had a big stove fired night and day, on the north side were frozen bone hard, and they were covered by hoar frost. I broke off about one-fourth of a block and wrapped it in a paper and placed it in the drawer in my room. I thought that one frost, no matter how strong it was, could not destroy the hardening capacity, but only stop the process, as the frozen water is a solid substance by which the hardening process is only stopped. Thus my opinion was proved after three or four days, as the soft and brittle piece of the concrete block thawed out and the hardening process completed satisfactorily; but the wrapping paper was thoroughly

soaked with water. I remarked before that the blocks on the north side of the tent were covered with hoar frost. This happened because the blocks are better conductors of heat than the air, and so the moisture of the air precipitated on the blocks, forming, after the temperature went under the freezing point, hoar frost on them. After thawed out this precipitated moisture furnished extra moisture for the blocks, which helped the cement to perfect crystalization, but, indeed, in my case, wet also the wrapping, which was a sign that water was present in abundance.

These blocks were made out of a dry mixture which is absolutely necessary in winter time. As when the water passes over a certain percentage, even so by the first freezing the cohesion will be entirely destroyed, which I observed in different cases when soft concrete was poured in forms building up walls. So far as the frost penetrated the concrete became entirely loose, and could be brushed off with even a soft brush.

Cost of the Complete Wall.

The costs of the complete wall are composed:

- (1) Concrete blocks on the ground.
- (2) Cost of materials for mortar.
- (3) Labor.
- (4) Staging.

I will show in the following a general example how to calculate the costs of the concrete wall:

- (1) Concrete block, $24 \times 8 \times 8$ ins. in the factory.. 10 cents.
Handling and hauling to the place where the building has to be erected, average..... 2 "

Total costs = 12 cents.

- (2) Mortar: 1 cement and 3 sand.

For 100 blocks are necessary about 9 cu. ft. mortar.

Cement $\frac{9}{3}$: 3.6 = 0.834 bbl. at \$1.80 = \$1.50

Sand $\frac{9}{27}$ = 0.333 at 60 cents =20

Total \$1.70

also, per block 1.7.

A mason can lay on an average of 10 blocks in one hour, including pointing, so 40 cents. divided by 10 = 4 cents per block.

Now suppose a gang of 5 masons working on the place 8 hours each = 40 hours, making 10 blocks an hour = 400 blocks. These 400 blocks having the dimensions of $24 \times 8 \times 8$ ins., will cover 530 sq. ft. The total cost of the 530 sq. ft. wall will be:

400 concrete blocks at 12 cents.....	= \$48.00
Mortar 400 \times 1.7 cents.	= 6.80
Masons 400 blocks at 4 cents.	= 16.00
Helpers:	
1 mortar mixer.	
1 mortar carrier.	
3 block carriers.	
2 pulling up mortar and blocks.	

Total 7 helpers at 8 hrs. = 56 hrs. at 18 cents = 10.08

1 foreman 4.00

Staging made out, barrel or horses, material and handling 2.00

Total \$86.92

8692c.

= 16.4 per sq. ft.

530 sq. ft.

Profit, 25%... 4.1c.

Total..... 20.5c. per sq. ft. complete wall, made out of complete blocks.

Concrete wall of 8 in. is at least as good as brick wall 13 in., as the blocks are at least as strong as any brick of middle quality, and, laid in cement mortar, concrete blocks make almost a monolithic wall.

By comparing a concrete block wall with a wall made out of bricks, it must be supposed that pressed face-bricks were applied, 7 pieces to the square foot, and backed with common red brick. The 13-in. wall contains per sq. ft. 21 bricks. The cost of the ready brick wall is composed as follows:

7 pressed face bricks, at \$30.00 per 1,000, ready in wall.....	= 21 cents.
14 common red brick at \$10.00 per 1,000, ready in wall.....	= 14 "
Total	<u>35 cents.</u>

APPENDIX 1.

RULES AND REGULATIONS COVERING THE MANUFACTURE AND USE OF HOLLOW CONCRETE BUILDING BLOCKS IN THE CITY OF PHILADELPHIA.

1. Hollow concrete building blocks may be used for building six stories or less in height, where said use is approved by the Bureau of Building Inspection, provided, however, that such blocks shall be composed of at least one (1) part of standard Portland cement, and not to exceed five (5) parts of clean, coarse, sharp sand or gravel, or a mixture of at least one part of Portland cement to five (5) parts of crushed rock or other suitable aggregate. Provided further, that this section shall not permit the use of hollow blocks in party walls; said party walls must be built solid.

2. All material to be of such fineness as to pass a $\frac{1}{2}$ -in. ring and be free from dirt or foreign matter. The material composing such blocks shall be properly mixed and manipulated, and the hollow space in said blocks shall not exceed the percentage given in the following table for different height walls, and in no case shall the walls or webs of the block be less in thickness than one-fourth of the height. The figures given in the table represent the percentage of such hollow space for different height walls.

Stories.	1st.	2d.	3d.	4th.	5th.	6th.
1 and 2	33	33				
3 and 4	25	33	33	33		
5 and 6	20	25	25	33	33	33

3. The thickness for walls for any building where hollow concrete blocks are used shall not be less than is required by law for brick walls.

4. Where the face only is of hollow concrete building block and the backing is of brick, the facing of hollow concrete blocks must be strongly bonded to the brick either with headers projecting 4 ins. into the brick work, every fourth course being a heading course, or with approved ties, no brick backing to be less than 8 ins. Where the walls are made entirely of hollow concrete blocks, but where said blocks have not the same width as the wall, every fifth course shall extend through the wall, forming a secure bond. All nails where blocks are used shall be laid up in Portland cement mortar.

5. All hollow concrete building blocks before being used in the construction of any buildings in the City of Philadelphia shall have attained the age of at least three (3) weeks.

6. Wherever girders or joists rest upon walls so that there is a concentrated load on the block of over two (2) tons, the blocks supporting the girder or joists must be made solid. Where such concentrated load shall exceed five (5) tons, the blocks for two (2) courses below, and for a distance extending at least 18 ins. each side of said girder shall be made solid. Where the load on the wall from the girder exceeds five (5) tons, the blocks for three (3) courses underneath it shall be made solid with similar material as in the blocks. Wherever walls are decreased in thickness the top course of the thicker wall to be made solid.

7. Provided always that no wall or any part thereof composed of hollow concrete blocks shall be loaded to an excess of eight (8) tons per superficial foot of the area of such blocks, including the weight of the wall, and no blocks shall be used that have an average crushing at less than 1,000 lbs. per sq. in. of area at the age of 28 days, no deduction to be made in figuring the area for the hollow spaces.

8. All piers and buttresses that support loads in excess of five (5) tons shall be built of solid concrete blocks for such distance below as may be required by the Bureau of Building Inspection. Concrete lintels and sills shall be reinforced by iron or steel rods in a manner satisfactory to the Bureau of Building Inspection, and any lintels spanning over 4 ft. 6 ins. in the clear shall rest on solid concrete blocks.

9. Provided, that no hollow concrete building blocks shall be used in the construction of any building in the City of Philadelphia, unless the maker of said blocks has submitted his product to the full test required by the Bureau of Building Inspection, and placed on file with said Bureau of Building Inspection, a certificate from a reliable testing laboratory showing that samples from the lot of blocks to be used have successfully passed the requirements of the Bureau of Building Inspection, and filing a full copy of the test with the Bureau.

10. A brand or mark of identification must be impressed in or otherwise permanently attached to each block for purpose of identification.

11. No certificate of approval shall be considered in force for more than four months unless there be filed with the Bureau of Building Inspection of the City of Philadelphia, said samples to every four months following, a certificate from some reliable physical testing laboratory showing that the average of three (3) specimens tested for compression, and three (3) specimens tested for transverse strength comply with the requirements of the Bureau of Building Inspection of the City of Philadelphia, samples said to be selected either by a building inspector or by the laboratory, from

blocks actually going into construction work, samples must not be furnished by the contractors or builders.

12. The manufacturer and user of any such hollow concrete blocks as are mentioned in this regulation, or either of them, shall at any and all times have made such tests of the cements used in making such blocks or such further tests of the completed blocks, or of each of these, at their own expense, and under the supervision of the Bureau of Building Inspection, as the Chief of said Bureau shall require.

13. The cement used in making said blocks shall be Portland cement, and must be capable of passing the minimum requirements as set forth in the "Standard Specifications for Cement" by the American Society for Testing Materials.

14. Any and all blocks, samples of which on being tested under the direction of the Bureau of Building Inspection, fail to stand at 28 days the tests required by this regulation, shall be marked condemned by the manufacturer or user and shall be destroyed.

15. No concrete blocks shall be used in the construction of any building within the City of Philadelphia until they shall have been inspected, and average samples of the lot tested, approved and accepted by the Chief of the Bureau of Building Inspection.

SPECIFICATIONS GOVERNING METHOD OF TESTING HOLLOW BLOCK.

1. These regulations shall apply to all new materials such as are used in building construction, in the same manner and for the same purposes, as stones, brick, concrete, are now authorized by the building laws, when said new material to be substituted departs from the general shape and dimensions of ordinary building brick and more particularly to that form of building material known as hollow concrete block manufactured from cement and a certain addition of sand, crushed stone or similar material.

2. Before any such material is used in buildings, an application for its use and for a test of the same must be filed with the Chief of the Bureau of Building Inspection. A description of the material and a brief outline of its manufacture and proportions of the material used must be embodied in the application.

3. The material must be subjected to the following tests: Transverse, compression, absorption, freezing and fire. Additional tests may be called for when, in the judgment of the Chief of the Bureau of Building Inspection, the same may be necessary. All such tests must be made in some laboratory of recognized standing, under the supervision of the engineer of the Bureau of Building Inspection. The tests will be made at the expense of the applicant.

4. The results of the tests, whether satisfactory or not, must be placed on file in the Bureau of Building Inspection. They shall be open to inspection upon application to the Chief of the Bureau, but need not necessarily be published.

5. For the purposes of the tests, at least twenty (20) samples or test pieces must be provided. Such samples must represent the ordinary commercial product. They may be selected from stock by the Chief of the Bureau of Building Inspection, or his representative, or may be made in his presence, at his discretion. The samples must be of the regular size and shape used in construction. In cases where the material is made and used in special shapes and forms too large for testing in the ordinary machines, smaller sized specimens shall be used as may be directed by the Chief of Bureau of Building Inspection, to determine the physical characteristic specified in Section 3.

6. The samples may be tested as soon as desired by the applicant, but in no case later than 60 days after manufacture.

7. The weight per cubic foot of the material must be determined.

8. Tests shall be made in series of at least five, except in the fire tests a series of two (four samples) are sufficient. Transverse tests shall be made on full-sized samples. Half samples be used for the crushing, freezing and fire tests. The remaining samples are kept in reserve, in case unusual flaws, or exceptional or abnormal conditions, make it necessary to discard certain of the tests. All samples must be marked for identification and comparison.

9. The transverse tests shall be made as follows: The sample shall be placed flatwise on two rounded knife edge bearings parallel, 7 ins. apart. A load is then applied on top, midway between the supports, and transmitted through a similar rounded knife edge, until the sample is ruptured. The modulus of rupture shall then be determined by multiplying the total breaking load in pounds by 21 (three times the distance between supports in inches) and then dividing the result thus obtained by twice the product

the width in inches by the square of the depth in inches. $R = \frac{3W}{21d^2}$

No allowance should be made in figuring the modulus of rupture for the hollow spaces.

10. The compression test shall be made as follows: Samples must be cut from blocks so as to contain a full web section; samples must be carefully measured, then bedded flatwise in plaster of Paris to secure a uniform bearing in the testing machine and crushed. The total breaking load is then divided by the area in compression in square inches. No deduction to be made for hollow spaces. The area will be considered as the product of the width by the length.

11. The absorption tests must be made as follows: The sample is first thoroughly dried to a constant weight. The weight must be carefully recorded. It is then placed in a pan or a tray of water, face downward, immersing it to a depth of not more than $\frac{1}{2}$ inch. It is again carefully weighed at the following periods: 30 minutes, four hours, and 48 hours, respectively, from the time of immersion. It is again replaced in the water in each case as soon as the weight is taken. Its compressive strength, while still wet, is then determined at the end of the 48-hour period in the manner specified in Section 10.

12. The freezing tests are made as follows: The sample is immersed, as described in Section 11, for at least four hours and then weighed. It is then placed in a freezing mixture or a refrigerator, or otherwise subjected to a temperature of less than 10° F. for at least 12 hours. It is then removed and placed in water, where it must remain for at least one hour, the temperature of which must be at least 150° F. This operation is repeated ten times, after which the sample is again weighed while still wet from the last thawing.

Its crushing strength should then be determined as called for in Section 10.

13. The fire test must be made as follows: Two samples are placed in a cold furnace in which the temperature is gradually raised to 1,700° F.; the test piece must be subjected to this temperature for at least 30 minutes. One of the samples is then plunged in cold water (about 50° F. to 60° F.) and the results noted. The second sample is permitted to cool gradually in air, and the results noted.

14. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at 28 days old must average 150 and must not fall below 100 in any case. The ultimate compressive strength at 28 days must average 1,000 lbs. per sq. in., and must not fall below 700 lbs. in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15% and must not exceed 20% in any case. The reduction of compressive strength must not be more than 33⅓%, except that when the lower figure is still above 1,000 lbs. per sq. in. the loss in strength may be neglected. The freezing and thawing process must not cause a loss in weight greater than 10% nor a loss in strength of more than 33⅓%, except that when the lower figure is still above 1,000 lbs. per sq. in. the loss in strength may be neglected. The fire test must not cause the material to disintegrate.

15. The approval of any material is given only under the following conditions:

(a) A brand mark for identification must be impressed on or otherwise attached to the material.

(b) A plant for the production of the material must be in full operation when the official tests are made.

(c) The name of the firm or corporation and the responsible officers must be placed on file with the Chief of the Bureau of Building Inspection, and changes in the same promptly reported.

(d) The Chief of the Bureau of Building Inspection may require full tests to be repeated on samples selected from the open market, when, in his opinion, there is any doubt as to whether the product is up to the standard of these regulations and the manufacturer must submit to the Bureau of Building Inspection once in at least every four months a certificate of tests showing that the average resistance of three specimens to cross breaking and crushing are not below the requirements of these regulations. Such tests must be made by some laboratory of recognized standing on samples selected by a building inspector or the laboratory from material actually going into construction, and not on ones furnished by the manufacturer.

CONCRETE BLOCKS

(e) In case the results of tests made under these conditions should show that the standard of these regulations is not maintained, the approval of this bureau to the manufacturer of said blocks will at once be suspended or revoked.

Tests made under the specifications of the City of Philadelphia on concrete blocks in the market here have developed about the following results: Modulus of rupture, 150 to 175 lbs.; compressive strength, 1,200 to 1,600 lbs. per sq. in.; absorption, 5%.

The compressive strength is reduced little, if any, by the water absorbed. Freezing tests show little loss. The average compressive strength after freezing is in the vicinity of 1,000 lbs. per sq. in. The blocks passed the fire tests well.

APPENDIX II.

To aid those readers who desire to avail themselves of the descriptive pamphlets and similar trade literature issued by the various concerns making concrete block machines, molds and tools the following list of manufacturers has been compiled:

- American Hydraulic Stone Co., Denver, Colo.
- Automatic Building Block Machine Co., Jackson, Mich.
- Blakeslee Concrete Block Machine Co., Columbus, O.
- Brady Cement Stone Machine Co., Jackson, Mich.
- Cement-Normandin Machinery Co., Jackson, Mich.
- Cement Machinery & Mfg. Co., Burlington, Ia.
- Cement Working Mach'y Co., 193 Lafayette Ave., Detroit, Mich.
- Century Cement Machine Co., 181 Main St., W. Rochester, N. Y.
- Coltrin Mfg. Co., Jackson, Mich.
- Concrete Construction Co., 3 Broad St., New York City.
- (Machines for Export.)
- Cottom Artificial Stone & Mfg. Co., Dayton, O.
- Drake Standard Machine Co., 300 Jackson Boulevard, Chicago.
- K. Dykema & Son, Grand Rapids, Mich.
- Z. Fielder & Son, 1017 Broadway, Hannibal, Mo.
- H. E. Goodwin, 208 Blake St., Indianapolis, Ind.
- Hayden Automatic Block Machine Co., Columbus, O.
- Ideal Concrete Machinery Co., South Bend, Ind.
- International Concrete Block Machine Co., Minneapolis, Minn.
- Iowa Building Block Machine Co., Waterloo, Ia.
- L. D. Libby, 238 Second Ave., South Minneapolis.
- Michigan Cement Block Machinery Co., Union City, Mich.
- Miles (P. B.) Mfg. Co., Jackson, Mich.
- Miracle Pressed Stone Co., Minneapolis, Minn.
- National Hollow Concrete Machine Co., Washington, D. C.
- Nolan & Layman, 2801 18th Ave., South Minneapolis, Minn.

- Harmon S. Palmer Co., 1450 Binney St., Washington, D. C.
Noyes F. Palmer Mfg. Co., 150 Snediker Ave., Brooklyn, N. Y.
Pettyjohn Bros., Terre Haute, Ind.
Scott Mfg. Co., Commonwealth Trust Building, St. Louis, Mo.
W. J. Scoutt, 60 West Washington St., Chicago, Ill.
E. W. Seamans, Grand Rapids, Mich.
Simplex Mfg. Co., Jackson, Mich.
Standard Stone Co. of America, 140 Nassau St., New York City.
Standard Sand & Machine Co., Cleveland, O. (1509 St. Clair St.).
Stevens Cast Stone Co., 608 Chamber of Commerce, Chicago, Ill.
Stewart Cement Block Machine Co., Waterloo, Ia.
Stringer Machine Co., Jackson, Mich.
Underwood Building Block Machine Co., Columbus, O.
U. S. Cement Shingle Machinery Co., Saginaw, Mich.
Universal Concrete Machine Co., Norfolk, Va.
Variety Machine Mfg. Co., 116 First Ave. N., Minneapolis, Minn.
Waterloo Automatic Stone Machine Co., Waterloo, Ia.
Winget Concrete Machine Co., Columbus, O.
Winner Concrete Block Machine Co., Minneapolis, Minn.
Concrete Construction Co., Steubenville, O.,
(Manufacturers of Molds for Ornamental Construction).
A. H. Kennedy, Rockport, Ind.
(Template Puller for Concrete Blocks).
Collapsible Centering Construction Co., Detroit, Mich.
(Collapsible Centers for Concrete Conduits or Arches).
L. A. Pratt, Bay City, Mich.
(Galvanized Iron Flasks for Concrete Fence Posts).
J. A. Mitchell, Goshen, Ind., Concrete Fence Posts.
J. H. Emery, West Bay City, Mich., Cement Brick Machine.
Keystone Hollow Cement Block Machine Co., Phoenixville, Pa.
Hartwick Concrete Block Machine Co., Jackson, Mich.
Frost Concrete Stone Co., Waterloo, Ia.
Perfection Block Machine Co., Sioux Falls, S. D.
Bright & Co., No. High St., Columbus, O.
Auburn Concrete Machinery Works, Auburn, Ind.
Fishers Hydraulic Stone System, Memphis, Tenn.
Concrete Hollow Wall Constr. Co., 1520 Ashland Bk., Chicago.
Walton Granolithic Stone Machine Co., Kansas City, Mo.
W. P. Bryson, 939 N. Y. Life Building, Kansas City, Mo.
Diamond Cement Block Co., Rock Rapids, Ia.
Underwood Building Block Machine Co., Fostoria, O.
J. A. Noble, Fostoria, O.

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